# Architectural Heritage Recording Manuals

## a methodology for digital recording of buildings and monuments in Jerusalem


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WELFARE ASSOCIATION

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# Foreword

Cultural heritage is a unique and irreplaceable source of information. The process of acquiring heritage information serves for the identification of heritage places with significance at the local, national and/or international community.

Good decisions in heritage conservation are based on timely, relevant and accurate information about the conditions, materials and evolution of heritage buildings and landscapes. Therefore, documenting, recording and analysis of heritage places is an essential part of their conservation and management.

The rapid rise in new digital technologies has revolutionized the practice of recording heritage places. Digital tools and media offer a myriad of new opportunities for collecting, analyzing and disseminating information about heritage sites. With these new opportunities, there are also conflicts, and an intense effort to build digital media into the education of conservation professionals. Issues regarding the proper, innovative and research-focused uses of digital media in heritage conservation are an urgent topic in the global heritage conservation field, and the University College St. Lieven together with the Raymond Lemaire International Centre for Conservation (University of Leuven) have played a leading role in this area of cross-disciplinary research and practice. This training course offers a unique opportunity for professionals of heritage institutions in the Welfare Association to learn new approaches, best practices, and research results in the area of heritage information.

# Acknowledgements

The authors wish to acknowledge and thank the support of the Welfare Association Old City of Jerusalem Revitalization program for inviting to organize and implement an intensive course on Recording, Documentation and Information Management of Built Heritage.

It has been a unique opportunity to contribute to the capacity building of Palestinian experts in the recording of heritage places, and a privilege to work with Jerusalem's historic fabric.

In addition, we wish to thank the support of Dr. Shadia Touqan, Amal Abuelhawa, Hazem Quneibe and the Welfare Association staff in Jerusalem.

We must also acknowledge the hard work and crucial contribution of our senior expert member: Guido Kips; as well as, our junior experts Ona Vileikis and Barbara Fogarasi for their work. Special thanks to Kristine Loonbeek and the staff of the Leuven Research and Development for their help in logistics.

Finally, we would like to thank all those individuals and institutions that in one way or another helped with the completion of this manual.

# The Manuals

## a. Objectives

The manuals aim at providing an approach for the effective use of recording, interpretation, and information management systems in the conservation of built heritage.

The content strategy involves the presentation of innovative approaches and applications to:

- Develop an understanding of the role of information in conservation, addressing national and international standards;
- Review the potential limitations of recording and documentation techniques, including simple and advanced tools, and financial constraints;
- Develop a practical approach to the use of these tools and documentation techniques in order to capture information from cultural heritage resources;
- Include the use of information systems in cultural heritage resources management;
- Design reports for presenting information to stakeholders and decision makers; and
- Use of off-the-shelf online tools for information sharing.

## b. Topics

Recording tools – an understanding with an emphasis on low-cost:

- Global Position Systems (GPS) and geotagging of boundaries, features and other relevant issues related to the protection and management of the site;
- Scale-rectified photography using a levelled camera, control points, Photoshop and Computer Aided Design (CAD);
- Reflectorless Electronic Distance Measurement Total Station (REDM);
- Geographic Information Systems (GIS) for site information

## c. Manuals

A didactic package has been compiled with the following manuals

- Principles of documentation and recording of historic buildings and sites;
- REDM Total Station with Theolt;
- Rectified photography with Photoplan and AutoCAD;
- Basic GPS surveying and processing with GIS works; and
- Reference DVDs with essential readings, other publications and presentations during the course.

These manuals complement the lectures and training provided in July 2010.

## d. Instructors

**Mario E. Santana Quintero** is both professor at the University College St. Lieven (Belgium) and assistant professor at the Raymond Lemaire Centre for Conservation (University of Leuven) (Belgium). He is also a lecturer at the University of Pennsylvania (USA) and guest professor at the University of Aachen RWTH (Germany).

Along with his academia work, he is currently the Vice President of the ICOMOS Scientific Committee on Heritage Documentation (CIPA) and executive officer of the Virtual Systems and Multimedia Society.

Since 1997, he has participated as Cultural Heritage documentation consultant for UNESCO, World Monuments Fund, Getty Conservation Institute, UNDP, ICCROM, Euromed Heritage, Abu Dhabi Authority for Culture and Heritage, Welfare Association, and the Petra National Trust. The projects have been carried out in Afghanistan, Belgium, China, Cyprus, Egypt, France, Germany, Jordan, India, Iraq, Italy, Kazakhstan, Sudan, the Sultanate of Oman, Syria, United Arab Emirates, USA and Yemen.

**Guido Kips** is a professor in surveying at the University of Applied Sciences KaHo Sint-Lieven in Ghent, Belgium with an Engineering degree in mining engineering from the K.U.Leuven. He is responsible for the contacts with industry and surveying community. The cooperation with the department of construction and architecture and with the RLICC dates from only a few years ago. He is a member of the FIG: International federation of surveyors and of the European Thematic Network EEGECS. Moreover, he was responsible for the organisation of a postgraduate program for professional surveyors (2007 and 2008) and Master classes for surveyors at the KaHo Sint-Lieven.

**Ona Vileikis** is a doctoral researcher at the Raymond Lemaire International Centre for Conservation (RLICC), K.U. Leuven. She is working on the development of an Information System in view of the nomination of the Silk Road (Central Asia) as a serial World Heritage Site, contributing in bridging the gap between technology and heritage decision makers. Ona is an architect with international experience in heritage and conservation, and holds a Master of Arts in World Heritage Studies from the Brandenburg University of Technology Cottbus (Germany). These studies were accompanied by research in Australia and an internship at ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property), Rome. She is also a member of ICOMOS.

**Barbara Fogarasi** is a research assistant at the Raymond Lemaire International Centre for Conservation, KU Leuven, where she has previously completed the Master Programme in Conservation. Her main task is leading a comprehensive evaluation of a rehabilitation project by the Council of Europe on the Balkans. She received her undergraduate architecture degree at the University of Toronto, after which she completed a two-year postgraduate programme in monument protection at the Technical University of Budapest, Hungary. Before coming to Belgium, she worked at the State Centre for the Conservation and Restoration of Historic Monuments in Budapest, preparing surveys and restoration design for historic buildings.

# Architectural Heritage Recording Manuals

**Welfare Association, Jerusalem**

# 1 Principles of documentation and recording of historic buildings and sites

# 1. Introduction

Figure 1: making a reconnaissance survey using a GPS, Jerusalem 2010, author

Good decisions in heritage conservation are based on timely, relevant and accurate information about the conditions, materials and evolution of heritage buildings and landscapes. Therefore, documenting, recording and analysis of heritage places is an essential part of their conservation and management.

Heritage information plays an essential role in the adequate preparation, implementation and monitoring of conservation strategies. Good decisions in conservation are based on timely, relevant and sufficient information. For this reason, the acquisition and management of information is important for the understanding of cultural heritage.

The rapid rise in new digital technologies has revolutionized the practice of recording heritage places. Digital tools and media offer a myriad of new opportunities for collecting, analyzing and disseminating information about heritage sites. With these new opportunities, there are also conflicts, and an intense effort to build digital media into the education of conservation professionals.

The manuals provide a comprehensive guide on the selection of tools for heritage recording and documentation, the application of information systems in monitoring and the use of three-dimensional capturing and visualization techniques for virtualized reconstruction of heritage places.

*Why recording*

- **Create a permanent record:** that is capable of being communicated from generation to generation that could be available in case of destruction and/or alterations of the heritage's significance and integrity;
- **Protection leading to Conservation:** documentation is a strategic tool permitting informed decision by identification, interpretation, and classification of heritage places. As well as, for detecting issues/processes that might affect the significance and integrity of these properties. Information enhances the understanding of the subject. The resulting record enables the implementation of interventions (mitigations) required to provide protection and therefore its conservation;
- **Promotion leading to Participation:** the heightening of knowledge about a heritage place can be seen as a tool for promoting the participation of society in its conservation, as a tool of 'cultural tourism and regional development' (Thornes, R. & Bold, J. 1998, p. 3)[1]. Moreover, it serves to protect it from destruction due to lack of public awareness of its importance and to help in combating 'the theft of and illicit in cultural property on a global scale' (Thornes, R. & Bold, J. 1998, p. 3)[1]

A good selection and application of recording and documentation tools is assured, when preparing a comprehensive approach derived from the needs of the site baseline. This base information set should take into consideration the indicators defined by assessing the state of conservation and statement of significance of the heritage place.

# 2. Objectives

These manuals aim at providing an approach for the effective use of recording, interpretation, and information management systems in the conservation of built heritage.

This first part provides fundamentals and a comprehensive approach to the issues when recording heritage places for conservation. It provides fundamental concepts in heritage information, as well as, how to identify the aspects to be recorded. Finally, it provides a short overview of the selection of tools and limitations in the process of recording.

At the conclusion of the session, the participant will:

- Have a global understanding of the role of information in conservation, addressing national and international standards;
- Review the potential limitations of recording and documentation techniques, including simple and advanced tools, and the financial constraints.

In addition, the document provides a list of other references for reading, which are included in the reference DVD provided with the manuals.

# 3. Fundamentals

The concept and role of recording, documentation and information systems in the conservation of heritage places have evolved substantially in the past ten years.

In particular, this part of the manual provides an overview of issues contributed by relevant documents and initiatives in the practice of heritage recording. The reviewed documents are the following:

- The Venice Charter (1964)
- ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites (1996)
- UNESCO World Heritage Operational Guidelines (updated on 2008)
- RecorDIM Initiative (2003 – 2007)
- Guidance on inventory and documentation of the cultural heritage (2009)

### *The Venice Charter (1964)*

The documentation of monuments requires a high level of quality, ensuring a precise reproduction of the subject and its context. These statements have been already ascertained in particular from the very essence of heritage conservation charters, as for Article 2 on the Venice Charter (1964)[2], which states that:

"The conservation and restoration of monuments must have recourse to all the sciences and techniques, which can contribute to the study and safeguarding of the architectural heritage".

Furthermore, the precision required and type of reports are also stated by Article 16:

"In all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs. Every stage of the work of clearing, consolidation, rearrangement and integration, as well as technical and formal features identified during the course of the work, should be included. This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published".

Point out the following aspects:

- 'Precise documentation' in conservation works deals with the use of techniques that can acquire with precision and integrity the building and context geometry and texture.

- The 'analytical and critical report' deals with the production of assessments about the actual condition of the subject, especially in the adequate quality of the measured dataset of geometric and texture for the thematic mapping.

### *ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites (1996)*

These ICOMOS principles set the grounds of the actual recording of historic buildings, as it defines: "Recording is the capture of information which describes the physical configuration, condition and use of monuments, groups of buildings and sites, at points in time, and it is an essential part of the conservation process" (ICOMOS 1996) [3].

According to the ICOMOS (1996) Principles for the Recording of Monuments, Groups of Buildings and Sites, recording should be undertaken:

- when compiling a national, regional, or local inventory;
- as a fully integrated part of research and conservation activity;
- before, during and after any works of repair, alteration, or other intervention, and when evidence of its history is revealed during such works;
- when total or partial demolition,

destruction, abandonment or relocation is contemplated, or where the heritage is at risk of damage from human or natural external forces;
- during or following accidental or unforeseen disturbance which damages the cultural heritage;
- when change of use or responsibility for management or control occurs.

### *UNESCO World Heritage Operational Guidelines (OG)*

The nomination of World Heritage sites is governed by the "Operational Guidelines, which are periodically revised to reflect the decisions of UNESCO's World Heritage Committee". The World Heritage Convention is ratified and applied in more than 187 countries (UNESCO 2010)[4], making these guidelines the most recognized standards worldwide.

According to these guidelines, the following issues need to be provided at submission of a new nomination:

- Identification and description of the Property;
- Justification for Inscription;
- State of conservation and factors affecting the property;
- Protection and management;
- Monitoring;
- Documentation;

In terms of the boundaries, the OG clearly state: "The boundaries of the property being proposed shall be clearly defined, unambiguously distinguishing between the nominated property and any buffer zone (when present). Maps shall be sufficiently detailed to determine precisely which area of land and/or water is nominated"

Furthermore, "All necessary documentation to substantiate the nomination shall be provided. In addition to what is indicated above, this shall include photographs, 35 mm slides, and image inventory and photograph authorization form. The text of the nomination shall be transmitted in printed form as well as in electronic format (Diskette or CD-Rom)".

### *Recording, Documentation and Information Management Initiative (RecorDIM 2003 – 2007)*

The RecorDIM initiative has provided the opportunity to documentation and conservation professionals to improve the practice of collecting, processing and managing information for conservation of architectural heritage. In particular, the results presented in this manual show the use of technology specifically used for capturing our cultural heritage, effectively providing a reference source for applying metric survey tools for conservation of architectural heritage.

As part of the deliverables of this initiative, The Getty Conservation and partners have made the following two publications freely available online:

- Letellier, R. Schmid, W. LeBlanc, F. Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places, Getty Conservation Institute, 2007 J. Paul Getty Trust (available at: http://www.getty.edu/conservation/publications/pdf_publications/recordim.html)
- Eppich, E. Chabbi, A. ed. Illustrated Examples Recording, Documentation, and Information Management for the Conservation of Heritage Places, The Getty Conservation Institute, 2007 J. Paul Getty Trust (available at: http://www.getty.edu/conservation/publications/pdf_publications/recordim.html)

These two guidelines provide the grounds for the understanding, planning and implementation of heritage recording, documentation and information systems projects.

In particular the Guiding principles provides the following key definitions for:

- **Cultural heritage place (also heritage place, heritage asset)**: Used in this book to refer in general to immovable cultural heritage, such as archaeological sites, single

monuments, groups of buildings, historic towns, or cultural landscapes.

- **Documentation:** The already existing stock of information. As an activity, it stands for the systematic collection and archiving of records in order to preserve them for future reference. It can be said: Today's recording is tomorrow's documentation.
- **Heritage information:** The integrated activities of recording, documentation, and information management.
- **Heritage recording:** The graphic or photographic capturing of information describing the physical configuration, evolution, and condition of a heritage at known points in time.
- **Information management:** The process of finding, cataloguing, storing, and sharing information by making it accessible to potential users now and in the future.
- **Recording:** Used in this publication in a broad sense, meaning the acquisition of new information deriving from all activities on a heritage asset, including heritage recording, research and investigation, conservation, use and management, and maintenance and monitoring.
- **Research and investigation:** Used to describe in general a variety of activities aimed at the acquisition of information pertinent to increasing knowledge of a cultural heritage place. While research is related more to off-site surveys (e.g., archival research), investigation relates to the direct acquisition of information from the heritage place as a primary source. Recording is an essential component of research and investigation at each step and at each level of the conservation process.

### *Guidance on inventory and documentation of the cultural heritage (2009)*

The Council of Europe's Guidance on inventory and documentation of the cultural heritage[6] expresses that inventories are "indispensable, for the purposes of identification, protection, interpretation, and physical preservation of movable objects, historic buildings, archaeological sites, and cultural landscapes" (Council of Europe 2009, p. 11)[6]. This book provides not only a detailed explanation of inventories, but also a standard on how to produce records. Any organization starting a heritage resources inventory should obtain a copy of this book.

# 4. Heritage places assessment

The protection of heritage places is only possible with the inclusion of these resources in pre-inventories, inventories, national register, world heritage list or other legal instruments that identify the significance and integrity at national, regional and/or international levels.

This manual presents an approach and techniques to prepare a "measured dataset of representations" of a heritage place. This is an important part of the "heritage places assessment", which involves the definition of "statement of significance", analysis of threats affecting the integrity of the site and the actual state of conservation.

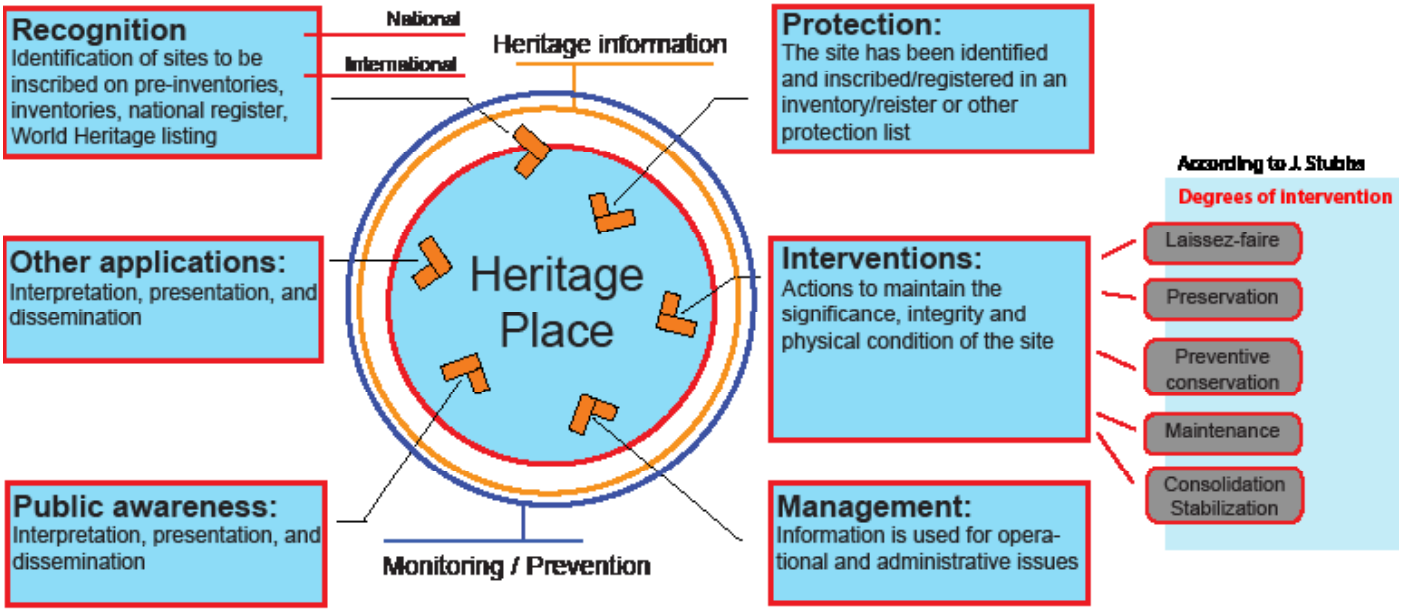



Chart 1: identification of heritage places, author.

Chart 1 provides the different levels of action, when a site is recognized, recording, documentation and information systems play an essential role in providing information for decision making in the process of identification, protection, mitigations, management, presentation and other actions.

Regarding heritage assessment, the relation between significance and integrity plays an essential role. Chart 2 illustrates this relation between evaluating a site and defining the heritage place's statement of significance. This is shown by the number of evidences by which these aspects (significance) are present in the fabric (integrity).

In addition, the results of the 'Heritage Place Assessment', including the statement of significance will serve as ground to define a "risk assessment" of the property by considering factors that could potentially affect the integrity of heritage places. These issues can be depicted from the UNESCO World Heritage Operational Guidelines:

- Development Pressures;
- Environmental Pressures;
- Natural Disasters and Preparedness;
- Visitor/tourism Pressures;
- Number of inhabitants within property, buffer zone;
- Threat of armed-conflict.

The evaluation of these threats will provide a number of indicators allowing defining the information heritage needs for this particular heritage place. These aspects are illustrated in chart 3.

In addition, indicators can be used for ensuring a monitoring system, where a heritage information system will play a crucial role to record information about these indicators.

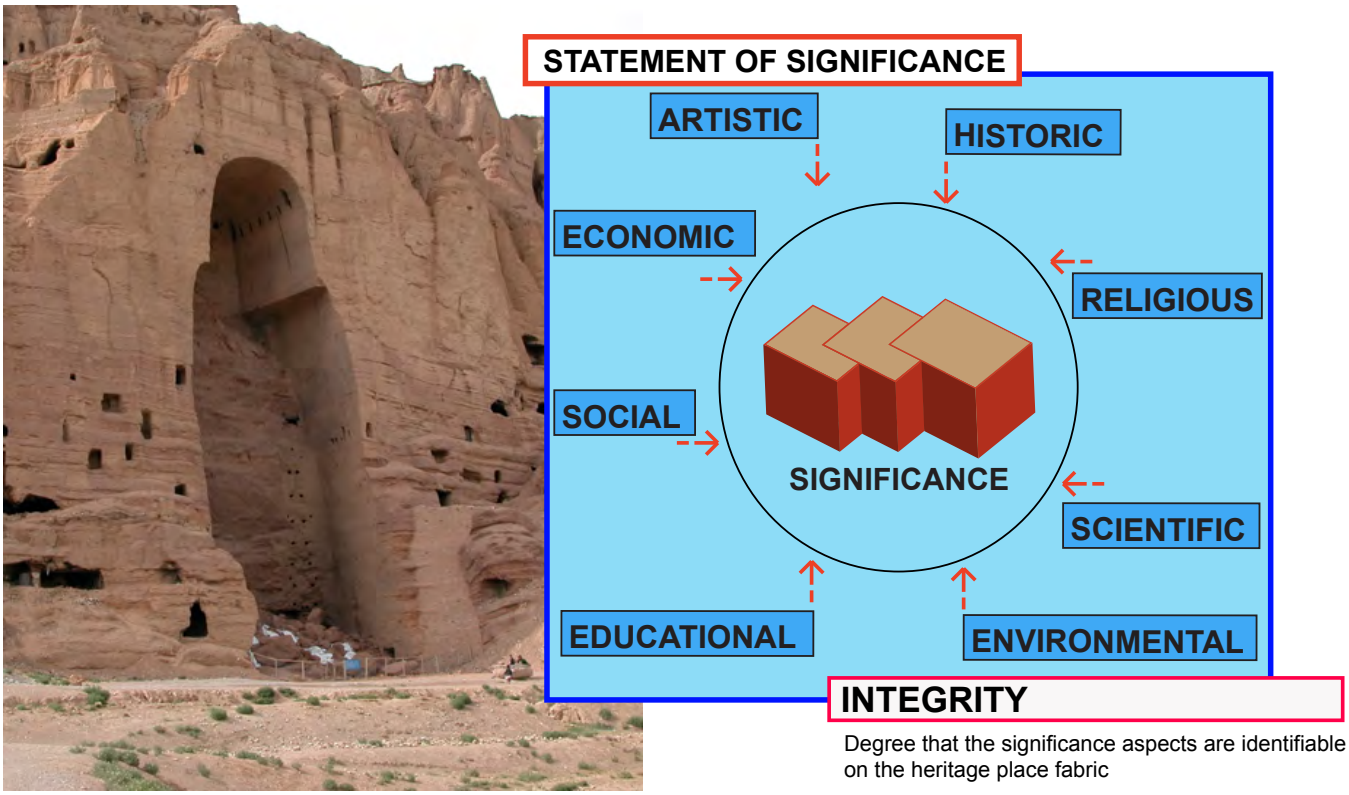



Chart 2: significance and integrity, based on the Iraq Cultural Heritage Conservation Initiative project (Getty Conservation Institute, 2004)[7]

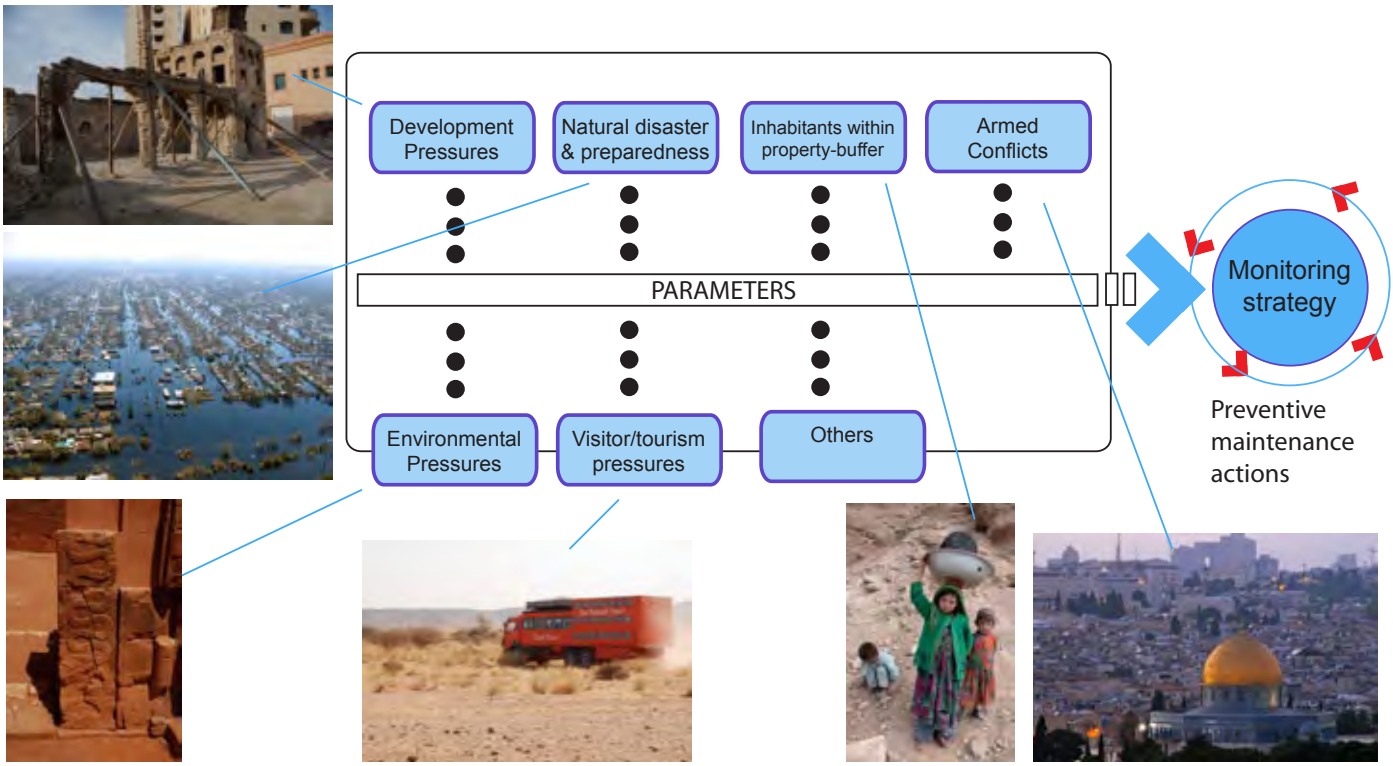



Chart 3: threats assessment, based on the UNESCO World Heritage Operational Guidelines (UNESCO)[4]

# 5. Conservation of heritage places

A heritage place conservation plan can be implemented using different approaches. In this manual a specific workflow approach is presented. It has been developed by Demas, M. and presented on chart 4. Heritage information plays an essential role in each of these four phases, as means of providing relevant and timely data to proceed and evaluate the role and action of each of the work phases.

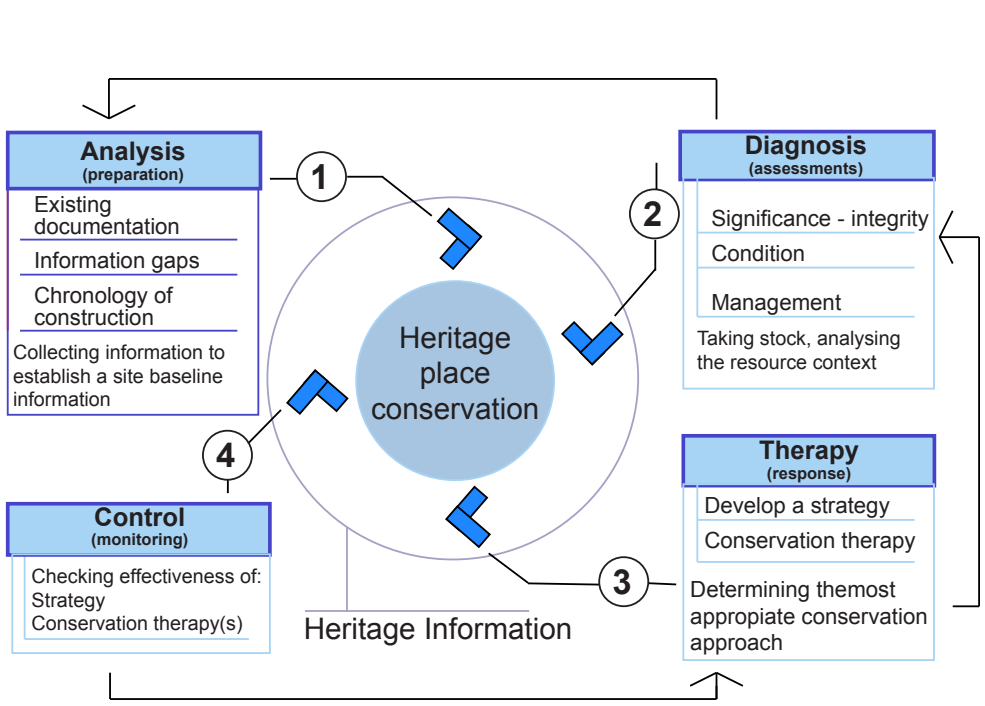


Chart 4: the conservation process, based on Demas, M. Planning for Conservation and Management of Archaeological Sites: A Values-Based Approach, Getty Conservation Institute[8]

# 6. Defining a Heritage Place Baseline

At this stage, this manual focuses on the definition of baseline defined for conservation of a heritage place, where preliminary or detailed levels are used.

This baseline, additionally, could be used as a starting point for designing and implementing plan monitoring strategy, allowing detecting changes affecting the statement of significance of the heritage place.

A baseline is defined by both a site report and a dossier of measured representations that could include a site plan, emplacement plan, plans of features, sections, elevations, three-dimensional models, etc.

This document pretends presenting an approach about preparing a baseline set of measured plans.

In order to identify the extent of field recording necessary, it is important to prepare a documentary research to review and identify gaps in the existing information (documentation) on the site. This first assessment will allow to estimate the degree of additional recording work required to prepare an adequate set of documents to mapped indicators.

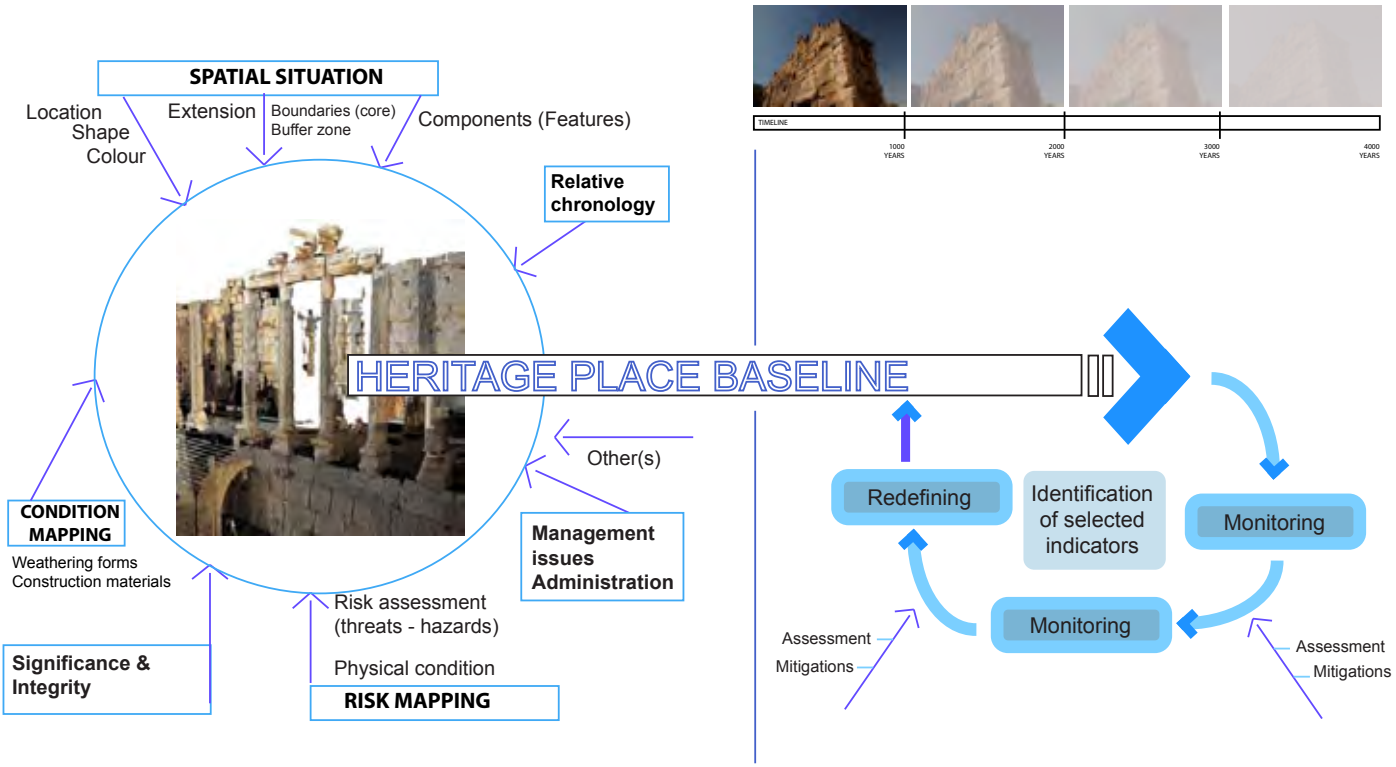



Chart 5: heritage place baseline (HPB), author.

The following checklist can be used as guideline to minimum requirements of information required to define the baseline:

- Identify site location (centroid, boundaries, elements and buffer zone);
- Identify and map evidences of criteria;
- Significance and integrity assessment;
- Risk assessment: threats and hazards associated to indicators;
- Administrative and management issues (current and passed mitigations);
- Other assessments.

Chart 5 illustrates the components of a "Heritage Place Baseline" (HPB), which provide all the

relevant information to understand the current situation of the resource studied. To complement the HPB, and following on the idea of threats affecting heritage places, chart 5 provides a list of causes of decay. These aspects have been defined by Gaul de Guichen at ICCROM and can serve to define a "damage atlas" affecting the site, which along with a measured dataset of representations can be used to identify the location and extend of these threats.

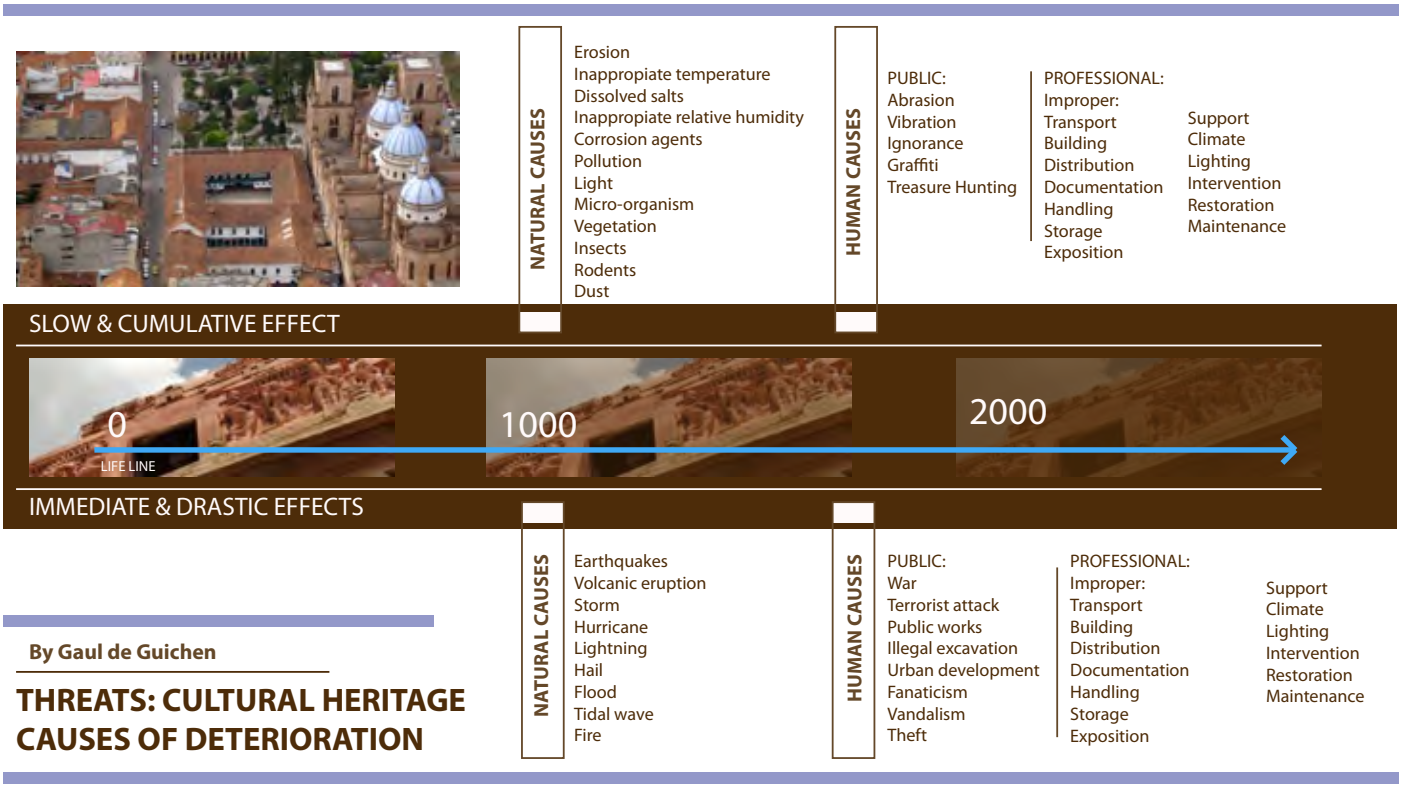



Chart 6: threats; cultural heritage causes of deterioration by Gaul de Guichen (ICCROM).

# 7. Recording heritage places

Recording for conservation of heritage places is a careful process that requires following these rules:

- Nothing is straight, square or horizontal
- Record from the wide (big) to the small (fault theory)
- For conservation: record as-built condition: record only what you see (make difference between what you see and assumptions deduced from "logical" way of fabric);
- Create a BASIS and CONTROL system
- Record and provide provenance information.

The heritage recorders should bear in mind that it is crucial to provide a measured dataset of representations that truly presents the actual state of conservation of the property.

Chart 7 illustrates the assessments required to define the Heritage Place Baseline (HPB)., taking into consideration the rules explained above.

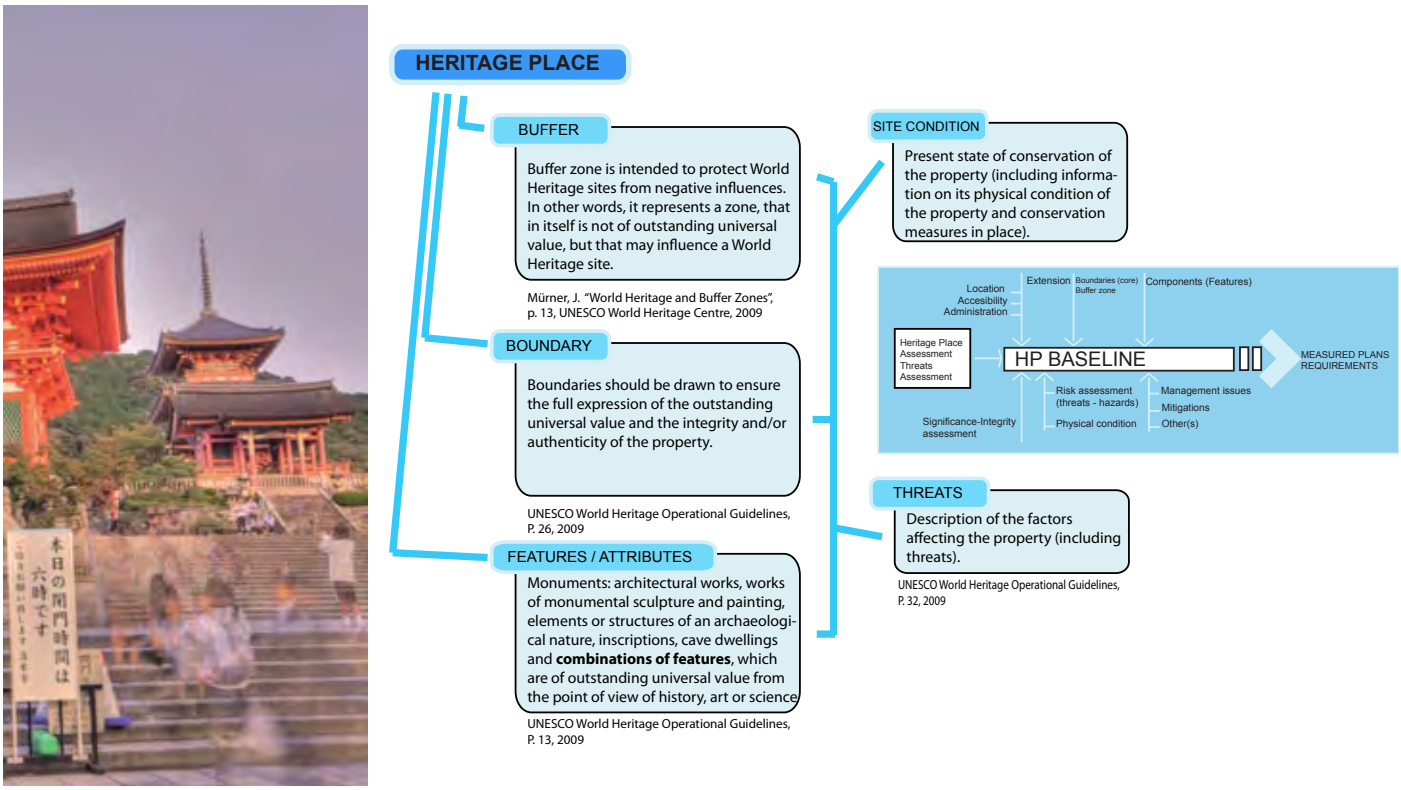

HERITAGE PLACE
BUFFER
Buffer zone is intended to protect World Heritage sites from negative influences. In other words, it represents a zone, that in itself is not of outstanding universal value, but that may influence a World Heritage site.
Mürner, J. "World Heritage and Buffer Zones", p. 13, UNESCO World Heritage Centre, 2009
BOUNDARY
Boundaries should be drawn to ensure the full expression of the outstanding universal value and the integrity and/or authenticity of the property.
UNESCO World Heritage Operational Guidelines, P. 26, 2009
FEATURES / ATTRIBUTES
Monuments: architectural works, works of monumental sculpture and painting, elements or structures of an archaeological nature, inscriptions, cave dwellings and combinations of features, which are of outstanding universal value from the point of view of history, art or science
UNESCO World Heritage Operational Guidelines, P. 13, 2009
SITE CONDITION
Present state of conservation of the property (including information on its physical condition of the property and conservation measures in place).
Location
Accesibility
Administration
Extension
Boundaries (core)
Buffer zone
Components (Features)
Heritage Place
Assessment
Threats
Assessment
HP BASELINE
MEASURED PLANS
REQUIREMENTS
Risk assessment
(threats - hazards)
Physical condition
Management issues
Mitigations
Other(s)
Significance-Integrity
assessment
THREATS
Description of the factors affecting the property (including threats).
UNESCO World Heritage Operational Guidelines, P. 32, 2009

Chart 7: Assessments required for the definition of the Heritage Place Baseline (HPS), based on the UNESCO World Heirtage Operational Guidelines

## a. Scope: levels of detail

The following levels, developed by Letellier (Getty Conservation Institute, pp. 36 - 38)[9] are presented here to provide an essential guide to define the amount of heritage information in terms of the "measured dataset of representations" required for a specific objective in understanding heritage places. These levels are:

- Reconnaissance;
- Preliminary;
- Detailed.

### *The Reconnaissance Record*

Usually, the reconnaissance record is an overview photo survey that will allow conservationists to visualize, in their entirety, a site and its related buildings and features in sufficient detail to understand the site's overall general characteristics. It should permit rapid identification of significant features and problem areas. The quantity of photos taken will vary with the size of the site and related structures and features, and the client's requirements. For a building, a reconnaissance record would normally include elevations together with significant details. More complex sites such as cultural landscapes or archaeological excavations will require general views from all compass points and at various height elevations (that is heights of land), supplemented, as needs dictate, by representative details.

### *The Preliminary Record*

Preliminary recording will complement the reconnaissance record by providing more complete information pertaining to the most significant elements of a site. The purpose of this record is to produce a record of the resource's major features. Additionally, the preliminary record could include data necessary for preliminary analysis, and define areas for further investigation and future 'detailed recording'. The accuracy of data is approximately ± 10 cm for plans, elevations, and cross sections, and ± 2 cm for structural data and structural details.

### *The Detailed Record*

Detailed recording may take place prior to, during or after a conservation activity so as to record a site's physical configuration, condition and significant features. Detailed recording occurs when a highly significant resource becomes the subject of directed research and analysis, or intervention planning and conceptual design. To ensure cost-effective detailed recording, completeness should be tailored to the immediate needs of a conservation team. Detailed recording may be phased over a number of years depending on planning requirements and related budget. The accuracy of a detailed record can vary between approximately ± 5 mm (for details) and ± 25 mm (for building plans).

Chart 8 provides an overview of the level of details; issues to record, accuracy, scale, recording tools associated to each level, and expected deliverables.

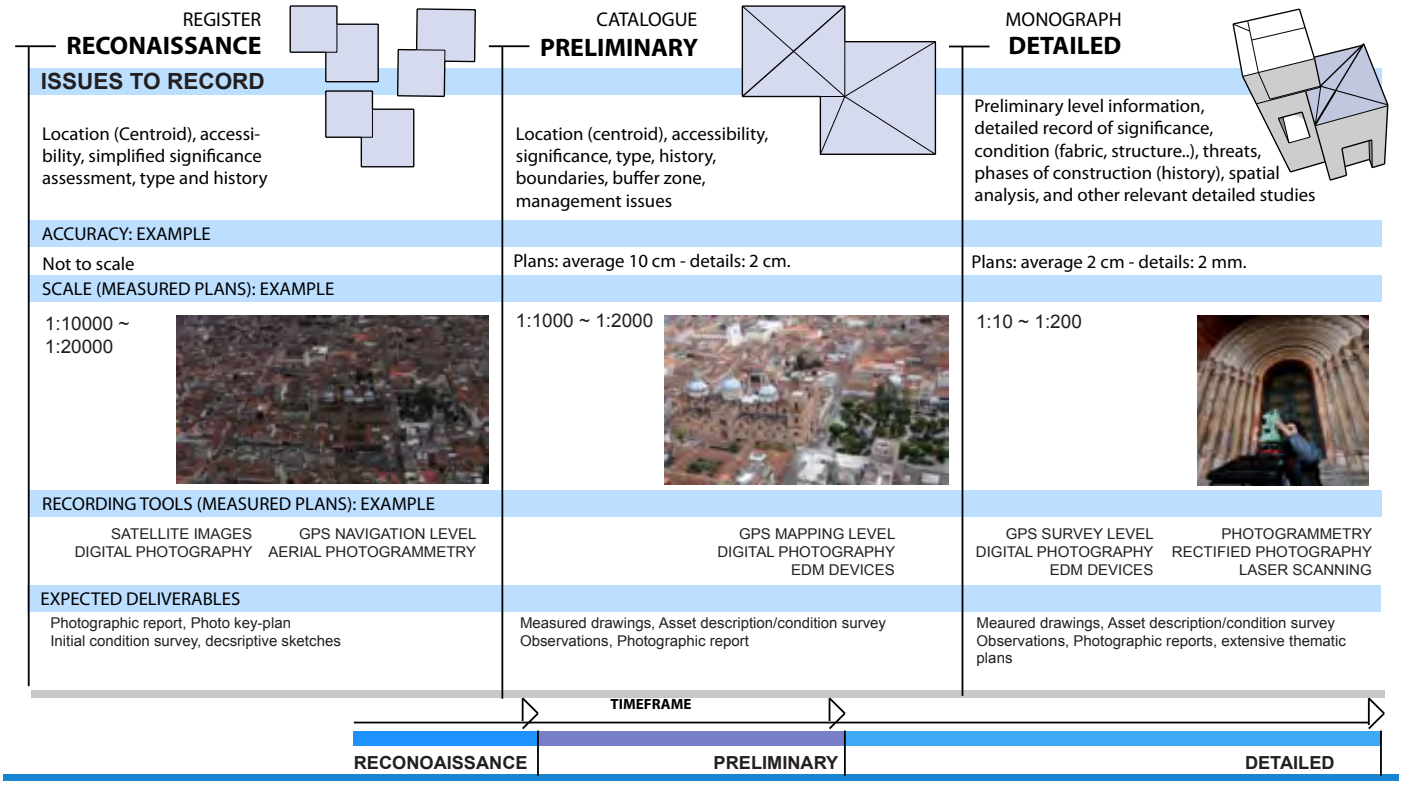



Chart 8: based on Letellier, R. Schmid, W. LeBlanc, F. Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places, Getty Conservation Institute, 2007 J. Paul Getty Trust[9]

# b. Planning for recording: selection of tools

The selection of tool(s) for recording heritage places requires a careful study of variables associated with the characteristics of sites (resources). These should be provided by the study of indicators to be mapped and the level of detail defined for the baseline measured representation dataset.

These resource variables should be compared with the technology (sensors) as well as available and accessible at hand. Information plays an essential role in decision making for conservation. An adequate strategy for capturing, storing and managing, that not only fulfils technical requirements, but is also adapted to the institutional and staff potentials will be the most effective way.

The following aspects have been defined to provide a guideline for this selection, chart 9:

- Heritage place;
- Organization;
- Project;
- Tool.

### *Heritage place variables*

These variables deal with the accessibility of the site. As shown in chart 9, a recording project will be impacted by the degree of time available to record on site, and this has a direct relation with the permitted (legal) time available, how to reach the site, height, extension, and the climatic conditions. For example, if the owner of the site allows to record the site only once a week for eight hours, and the level of record is detailed, this means that a faster technique capable of recording a great number of measurements is needed.

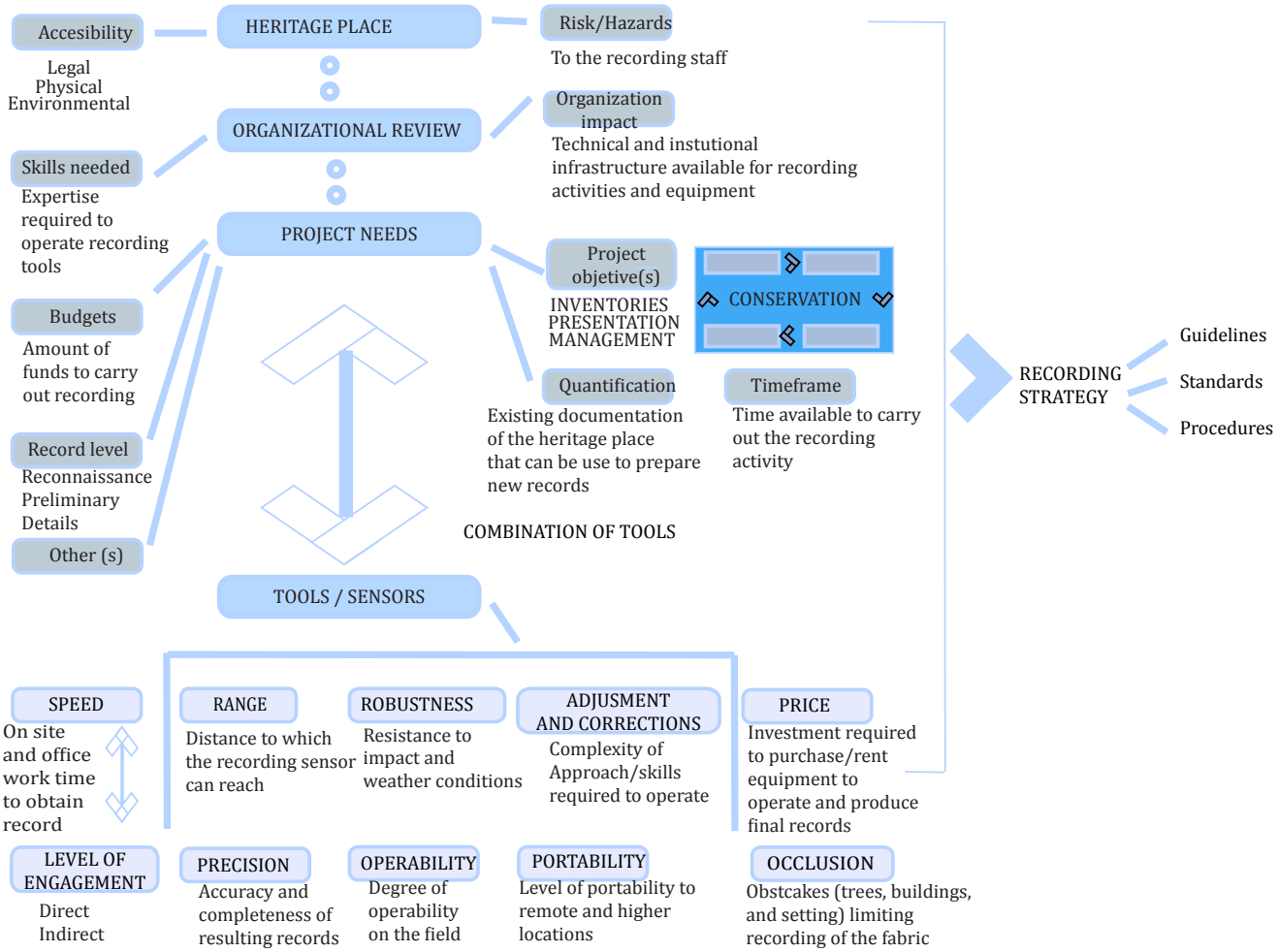



Chart 9: planning: selection of tool(s) for recording, author.

### *Organization variables*

These variables are associated to the current situation of the organization involved in the recording process, in many cases these variables assist in evaluating the need of outsourcing parts and/or the entire recording project.

Recording techniques require specific infrastructure and personnel skills to be use in a cost-effective way, this is a critical variable that is often neglected in many projects. A series of issues are explained in chart 9, illustrating the impact of these variables.

### *Project variables*

The project variables are aimed at defining what type of heritage information is to be recorded, according to the needs of an inventory, conservation strategy, preparation of a site management plan, maintenance plan, etc . The variables here presented and illustrated in chart 9 show key points to define the project needs, by evaluating the time, scale, consistency, extent and financial resources available for the work.

### *Tool (sensor, technique) variables*

It is important to define the impact relation between the previous set of variables and the parameters they provide to select an adequate set of tools.

In chart 9, a checklist of issues dealing with the operability of tools is provided, which list of issues allows to clarify the opportunities and limitations provided by:

- Speed: time to record an indicator.
- Precision: accuracy factor of the capturing equipment.
- Measuring Range: reach of the tool, depends on distance and other environmental constraints.
- Field operability: constraints in relation to the fieldwork.
- Robustness: strength to extend adverse weather conditions and impact.
- Portability: capability of being transported to remote sites, requirements of transport, power and other factors.
- Adjustment and corrections: processes required to obtain accurate results.
- Occlusion: respond to shadows, obstacles, and material related constraints (reflectivity)
- Price: rental and/or purchase of the sensor.

# c. Array of digital sensors

A vast range of digital tools exist for recording heritage places, these have been classified according to Addison's approach in the following categories:

- Visual (Still and video cameras)
- Dimensional (surveying, 3D scanning, photogrammetry, metrology, GPR)
- Locational (GPS, compass, …)
- Environmental (thermal, acoustic, C14, …)

Visual: technology capable of providing a visible impression of colour, shape and motion of a scene.

Dimensional: technology capable of providing a measure of spatial extent, with width, height, or length.
Locational: technology capable of providing the place where something is or could be located; a site, a location according to a national and/ or international coordinate system (ex. UTM, longitude-latitude, north orientation, etc).

Environmental: technology capable of providing information of potentially harmful factors originating in the environment, as well as, sensors providing 'dating' information, when a particular point or the period of time at which something happened or existed.

Chart 10 illustrates the ranges of sensors available. In this training package, a selection of tools have been made from visual, locational and dimensional sensors that have proven to be effective in heritage recording. Usage manuals have been prepared of these tools.

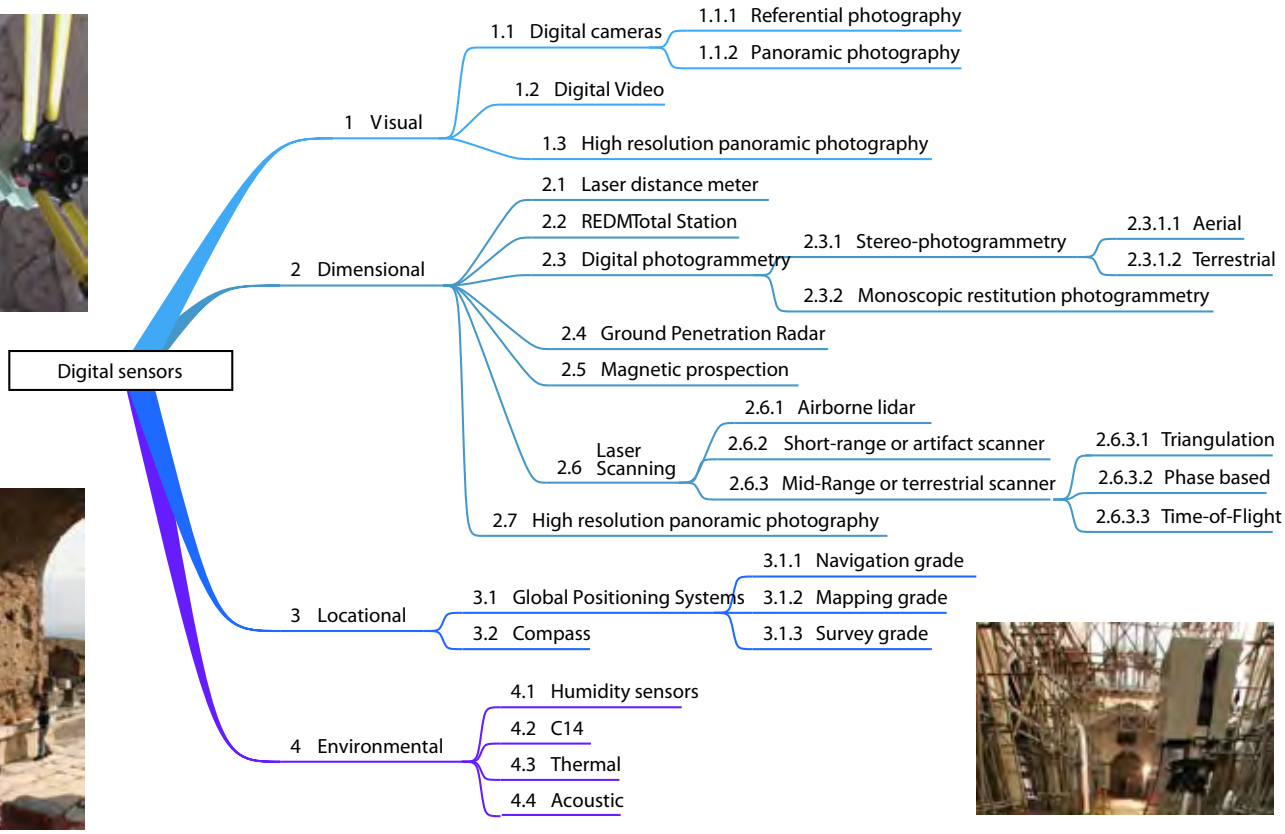



Chart 10: digital sensors based on A. Addison's research.

## d. Sources of error

Adequate identification of sources of error is very important in any heritage-recording project; Chart 11 based on research by Addison, Santana and Cravero (MACE, 2008, pp. 310)[10] illustrates these potential sources and explains eventual causes.

The timely and appropriate identification of how the sources of error illustrated on Chart 11, can determine the quality and precision of the resulting measured dataset of representation to be use as baseline information for other heritage assessment.

In many cases the lack of standards and guidelines affects the appropriate practice of recording. The first issue to tackle in an organization is a clear definition of these aspects, prior top carrying out recording at any level of detail.

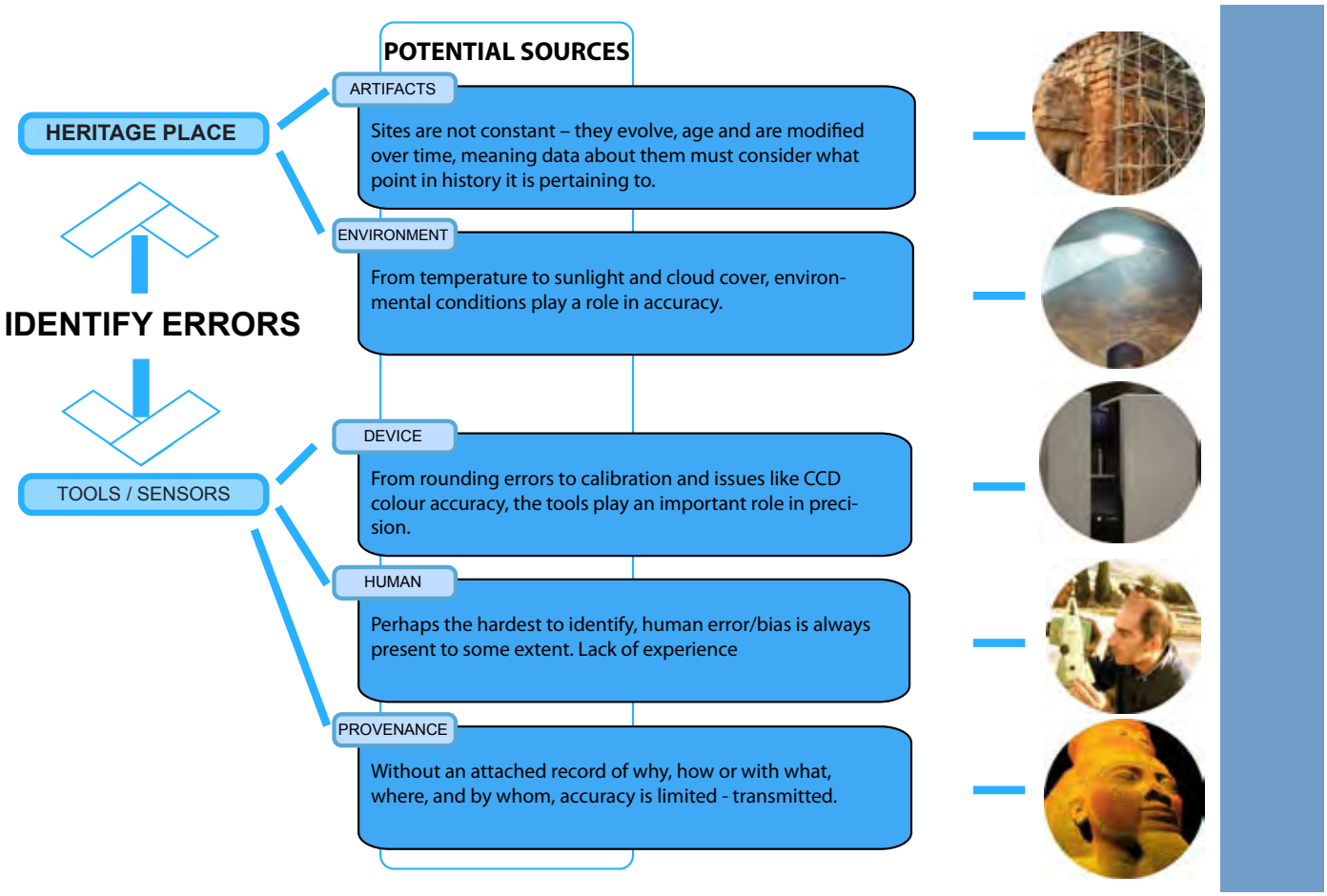

POTENTIAL SOURCES
HERITAGE PLACE
IDENTIFY ERRORS
TOOLS / SENSORS
ARTIFACTS
Sites are not constant – they evolve, age and are modified over time, meaning data about them must consider what point in history it is pertaining to.
ENVIRONMENT
From temperature to sunlight and cloud cover, environmental conditions play a role in accuracy.
DEVICE
From rounding errors to calibration and issues like CCD colour accuracy, the tools play an important role in precision.
HUMAN
Perhaps the hardest to identify, human error/bias is always present to some extent. Lack of experience
PROVENANCE
Without an attached record of why, how or with what, where, and by whom, accuracy is limited - transmitted.

Chart 11: sources of error, based on Addison, Santana and Cravero[10].

## e. Level of engagement

The use of tools for recording heritage places can be also classified according to the selection, time, skills and level of engagement required with the fabric to capture data from the site being studied. Chart 12, illustrates these aspects.

Selection: deals with the type of geometry captured by the sensor. For instance, using hand-survey, we are capturing points, distances, profiles, etc, while with laser scanning we are capturing three-dimensional shapes, points, and to some extend the colour of the fabric. Defining the type of information to be selected is of primarily importance when recording heritage places.

Time: relates to the time it takes to record features from the heritage place's fabric. For instance when using hand-survey the time required on site will be considerably more than at the office, while when using photogrammetry, the on site time is limited to taking photographs and defining a control system, and a larger office time is larger to restitute the geometry and colour of the fabric.

Level of engagement: this relates to the time of control system necessary to be defined, and the knowledge required of the site prior to recording the heritage place. For instance, with a GPS unit, the operator requires to select the points to define the boundaries of the site, while when using laser scanning, the 3D-shape of the object is fully recorded, although it is important to point out that knowledge of the site is always required, (see reconnaissance as the first level of detail required when studying heritage places)

Skills: it relates to the expertise required to operate a capturing tool to record the fabric of heritage places. For instance to record the centroid of a site using GPS and transfer that to a database, is a simple task that does not require much training, while using a GPS equipped with a mobile GIS application might require much more training but certainly the resulting survey will be more complete.

In addition to the requirements defined to prepare a site baseline, these parameters should be fully studied when considering recording heritage places.

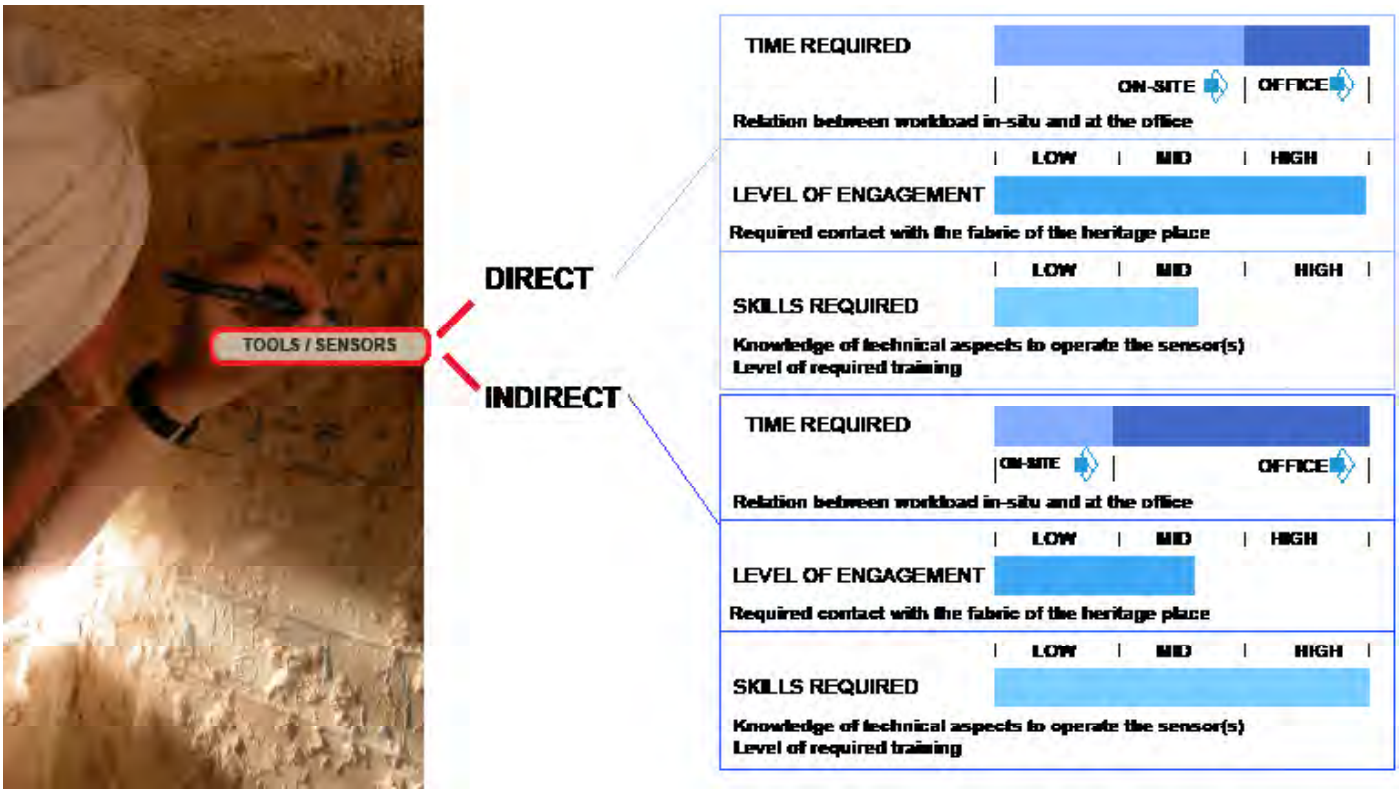



Chart 12: level of engagement for heritage recording projects, author.

# 8. Risk assessment: making a safety plan

This part explains the risks associated to the recording of heritage places, based on the study of the characteristics of the indicators to be recorded to prepare a site baseline information set.

Risks can be associated to:

- Hazard to the heritage recorder: including hazards when using scaffoldings, claiming high places, working underground, working in unstable structures, laser beams, and other when capturing the fabric of the place;
- Fabric deterioration risk: deals with potential deterioration and damage when entering in direct contact with the fabric of the heritage place and/or placing reference marks.

An effective assessment of the risks associated to recording the heritage place is very important. The use of hazardous techniques that can potentially damage the fabric of the heritage place should be avoided, as well as, recurring to recording tools that required direct contact with the fabric, when the heritage place is unstable.

# 9. Heritage recording projects: checklist

This checklist can be used to control that all required activities have been carried out in order to produce a "Measured Dataset of representations (dossier)" for the preparation of the Heritage Place Baseline report.

- [ ] REVIEW EXISTING DOCUMENTATION
- [ ] DIGITIZE RELEVANT EXISTING DOCUMENTATION
- [ ] **RECORD MORE INFORMATION TO DEFINE BASELINE (COMPLEMENTING EXISTING DOCUMENTATION)**
  - [ ] COLLECT BASIC INFORMATION
  - [ ] **PREPARE MEASURED MAPS**
  - [ ] ASSESS SIGNIFICANCE & INTEGRITY: DEFINE A STATEMENT OF SIGNIFICANCE
  - [ ] ASSESS STATE OF CONSERVATION: MATERIALS, CHRONOLOGY, CONDITION, ETC (IDENTIFY SOURCES OF DETERIORATION)
  - [ ] ASSESS THREATS (USE SWOT ANALYSIS: STRENGHS, WEAKNESSES, OPPORTUNITIES & THREATS)
  - [ ] DEFINE BOUNDARIES (CORE, BUFFER)
- [ ] **PREPARE AND DISSEMINATE DOSSIER WITH DOCUMENTATION**

# 10. Further references

### *Charters and guidelines*


- **ICOMOS charters:** (http://www.international.icomos.org/centre_documentation/chartes_eng.htm last visited 20/08/2010)
- **The Burra Charter**: http://www.icomos.org/australia/burra.html accessed 20/08/2010
- **Core Data Index to Historic Buildings and Monuments of the Architectural Heritage** Core data developed by the Getty http://www.object-id.com/heritage/intro3.html accessed 20/08/2010
- **Developing Data Standards from English Heritage's FISH** http://www.english-heritage.org.uk/server/show/nav.8331 accessed 20/08/2010
- **Documentation requirements for buildings proposed for demolition and standards for architectural documentation** http://www.coloradohistory-oahp.org/publications/pubs/1595.pdf accessed 20/08/2010
- Heritage Recording in the U.S. Article at **Preservation.net about the recording at the USA** http://www.epreservation.net/Resources/Articles/Detail.cfm?Article=20 accessed 20/08/2010
- **MIDAS**: A Manual and Data Standard for Monument Inventories Developed by English Heritage http://www.englishheritage.org.uk/upload/pdf/MIDAS3rdReprint.pdf accessed 20/08/2010
- **Utah's guidelines for measuring and photo documenting historic buildings** http://history.utah.gov/historic_preservation/information_and_research/measuringfloorplans.html accessed 20/08/2010


### *Recording tools and related publications*


- Benton, C. C. **Notes on Kite Aerial Photography** (Berkeley, California): http://arch.ced.berkeley.edu/kap/kaptoc.html accessed 20/08/2010
- Box, P. '**A manual for heritage managers.**', 1999. UNESCO http://www.unescobkk.org/index.php?id=3427&tx_mininews_pi1[showUid]=252&cHash=73667ec670 accessed 20/08/2010
- Getty Conservation Institute: **Documentation issue Fall 2005**: http://www.getty.edu/conservation/publications/newsletters/20_3/ accessed 20/08/2010
- Gillings, M. Wise, A.: **GIS Guide to Good Practice, AHDS Guides to Good Practice**, http://ads.ahds.ac.uk/project/goodguides/gis/index.html accessed 20/08/2010
- **Measured survey** (The Urban Conservation Glossary): http://www.trp.dundee.ac.uk/research/glossary/measured.html accessed 20/08/2010
- Panoramic photography: **WH Tour**: http://www.world-heritage-tour.org/ accessed 20/08/2010
- Wikipedia **'Panoramic Photography'**, 2007,:http://en.wikipedia.org/wiki/Panoramic_photography accessed 20/08/2010
- Santana Quintero, M. **The Use of 3D Documentation and Dissemination Techniques in Studying Built Heritage,** PhD related to the use of 3D Metric survey techniques in studying cultural heritage: http://www.3darchdoc.com/phd/ accessed 20/08/2010
- **USA Secretary of the Interior's Standards for Historical Documentation**: http://www.cr.nps.gov/local-law/arch_stnds_5.htm


### *Heritage place assessment*


- **Parks Canada Periodic Report on the Application of the World Heritage Convention** http://www.pc.gc.ca/docs/pm-wh/rspm-whsr/sec3/sec3c_e.asp accessed 20/08/2010

### *Organizations*

- **CIPA:** ICOMOS scientific committee on documentation of cultural heritage: The International Committee for Architectural Photogrammetry (CIPA) is one of the international committees of ICOMOS (International Council on Monuments and Sites) and it was established in collaboration with ISPRS (International Society of Photogrammetry and Remote Sensing). http://cipa.icomos.org

- **English Heritage's Metric Survey team**: it aims are to provide English Heritage with professional advice on all aspects of the Metric Survey process, relevant to the conservation of the historic environment. http://www.english-heritage.org.uk/server/show/nav.1155

- **The Getty Conservation Institute**: http://www.getty.edu/conservation

- **International Society for Photogrammetry and Remote Sensing (ISPRS)**: it is a non-governmental organization devoted to the development of international cooperation for the advancement of the photogrammetry, remote sensing, and spatial information sciences (SIS, GIS and LIS), and their applications. The Society operates without discrimination on the grounds of race, religion, nationality, or political philosophy. ISPRS is a 'Society of National and Regional Societies', which are Ordinary Members, Associate Members and Regional Members from 103 countries around the world, from which individuals are derived to participate in Society activities: http://www.isprs.org/

- **Recording, Documentation and Information Systems** (RecorDIM) Initiative: http://cipa.icomos.org/recordim

- **UNESCO World Heritage Centre:** http://whc.unesco.org/

- **Virtual Heritage Network**: an international organisation designed to promote the utilisation of technology for the education, interpretation, conservation and preservation of Natural, Cultural and World Heritage: http://www.virtualheritage.net/

- **Virtual Systems and MultiMedia Society** dealing with the use of Virtual Reality in research and industry, specialized in Virtual Heritage: http://www.vsmm.org

- **World Monuments Fund**: http://www.wmf.org

### *Recording and documentation initiatives*

- **Athar programme:** Documentation and Management of Heritage Sites in the Arab Region (ICCROM) http://www.iccrom.org/eng/prog2006-07_en/08athar_en/archive_en/2006_12documentation_en.shtml (Last reviewed 19/06/2007)

- **National Parks Service's Heritage Documentation Programs** (USA): http://www.nps.gov/history/hdp/ Information about programmes, standards, guidelines and opportunities.

- UNESCO's World Heritage Centre: **Development of a World Heritage Information Management capacity in the Arab States** http://whc.unesco.org/en/activities/58/ (Last reviewed 19/06/2007)

- World Monuments Fund – Getty **Conservation Institute Iraq Cultural Heritage Conservation Initiative** http://www.getty.edu/conservation/field_projects/iraq/index.html - http://www.wmf.org/iraq.html (accessed: 19/06/2010)

### *Other references*


- Bold, John A. **Guidance on heritage assessment**. Council of Europe, Strasbourg, France 2006.
- Clark, K. **Informed Conservation: Understanding historic buildings and their landscapes for conservation.**

English Heritage, 2001.
- Feilden, B. Jokilehto, J. **Management Guidelines for World Cultural Heritage Sites**, ICCROM, 1993.
- Letellier, R. **'unpublished training handout: Integrating RecorDIM activities to the Conservation Management Process'**, Ottawa 2006.
- Santana Quintero, M. **The Use of Three-dimensional Documentation and Dissemination Techniques in Studying Built Heritage, R. Lemaire International Centre for Conservation** (KU Leuven), 2003.
- Schuller, M. **Building Archaeology**, ICOMOS (Monuments and Sites: VII), Munich 2002.
- Spennemann, D.H.R. '**An integrated Architecture for Effective Heritage Site Management Planning**', CRM: The Journal of Heritage Stewardship, National Park Service, Vol 4/2 2007, pp. 18-28. Also available online at: ttp://crmjournal.cr.nps.gov/02_viewpoint_sub.cfm?issue=Volume%204%20Number%202%20Summer%202007&page=1&seq=2

## *Endnotes*

1. Thornes, R. & Bold, J. 'Documenting the Cultural Heritage', Council of Europe, Getty Information Institute and the European Foundation for Heritage Skills. Los Angeles 1998.
2. Charter of Venice (1964), ICOMOS charters: (http://www.international.icomos.org/centre_documentation/chartes_eng.htm accessed: 20/08/2010)
3. ICOMOS "Principles for the Recording of Monuments, Groups of Buildings and Sites" (1996) (http://www.international.icomos.org/recording.htm accessed: 20/08/2010)
4. UNESCO The Operational Guidelines for the Implementation of the World Heritage Convention (http://whc.unesco.org/en/guidelines accessed: 25/08/2010)
5. RECORDIM (http://www.getty.edu/conservation/field_projects/recordim/index.html accessed: 20/08/2010)
6. Council of Europe, 2009. "Guidance on inventory and documentation of the cultural heritage". Council of Europe Publishing: Strasbourg.
7. Getty Conservation Institute and World Monuments Fund Iraq Cultural Heritage Conservation Initiative (http://www.getty.edu/conservation/field_projects/iraq/ accessed: 20/08/2010)
8. Demas, M. "Planning for Conservation and Management of Archaeological Sites: A Values-Based Approach" Teutonico, J. Palumbo, G. ed. Management planning for archaeological sites: an international workshop organized by the Getty Conservation Institute and Loyola Marymount University, 19-22 May 2000, Corinth, Greece. ix+158 pages, 59 figures, 3 tables. 2002. Los Angeles (CA): Getty Conservation Institute; 0-89236-691-5, Getty Conservation Institute
9. Letellier, R. Schmid, W. LeBlanc, F. Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places, Getty Conservation Institute, 2007 J. Paul Getty Trust, pp. 36-38.
10. Santana Quintero, M. Addison, A. Cravero, S. "Digital Archives for Conservation and Management", BZambelli, M. Janowiak, A. Neuckermans, H. ed. "Browsing Architecture", Fraunhofer IRB verlag, Frankfurt 2008, pp. 310.

# 2 The toolbox, description of recording tools used in studying architectural heritage

# 1. Reflectorless Electronic Measurement Device (REDM) - Total Station

This section aims to provide a rough guide to the workings of EDM (Electronic Measurement Device), to give enough information to enable an understanding of the basic principles, and how they can affect choices made when considering working with such an instrument.

***An EDM is costly and fragile: it must be handled with care!***

## 1 Tools

**Hardware:**

Please review Equipment you need to check and bring with you to the site: for information about the contents of the equipment cases.

- Leica Builder 505 Total Station

- Tape measure

- Motion Computing Tablet PC

- Aluminium Tripod

- Umbrella

**Software:**

- AutoCAD v2007
- Theolt R7

Remember that high temperatures can affect your Total Station and Tablet PC, chose a desirable temperature for working, an umbrella and sufficient breaks to avoid any problems with the hardware.

***Check compliance of communication ports between the Total Station, Tablet PC and Theolt.***

***On the total station, please check settings of the communication port:***

1. Switch on the Total Station by pressing the ***red button*** on the side and hold for 3 seconds;

2. Using the upper yellow button press to tab ***Config***, press the middle buttom under the screen "COM" and check:
Data output: RS232: this means that the Total Station is writing to the cable and not to the external or USB memory;

- Baudrate: 19200
- Databits: 8
- Parity: None
- Endmark: CR/LF
- Stopbits: 1

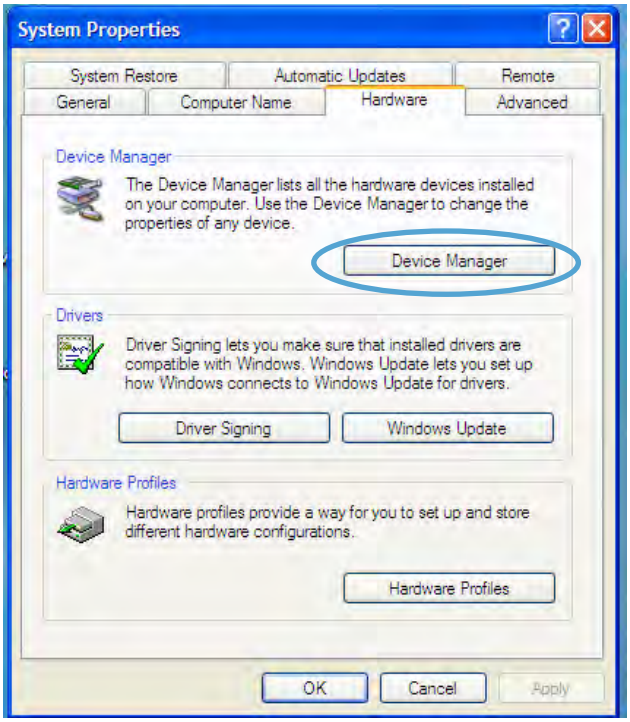
3. To change fields you need to use the arrows. When done press ***OK***.

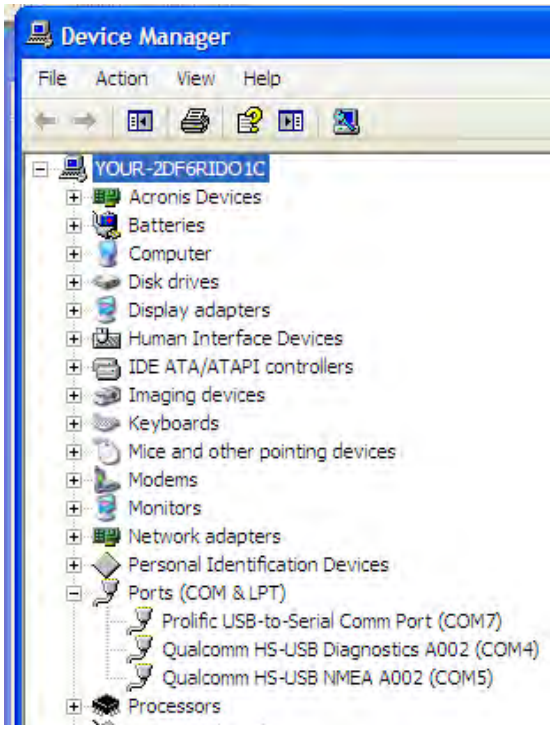
***On the Tablet PC:***

1. Connect the "Universal data Download Cable: Galaxyz" to the Total Station carefully and to the upper USB port of the Tablet PC, make sure that the connector is set to Leica;

2. Go to ***Start*** > ***My Computer*** and right click, select ***Properties***.

3. On ***System Properties*** screen, go to ***Hardware*** tab and select ***Device Manager***.

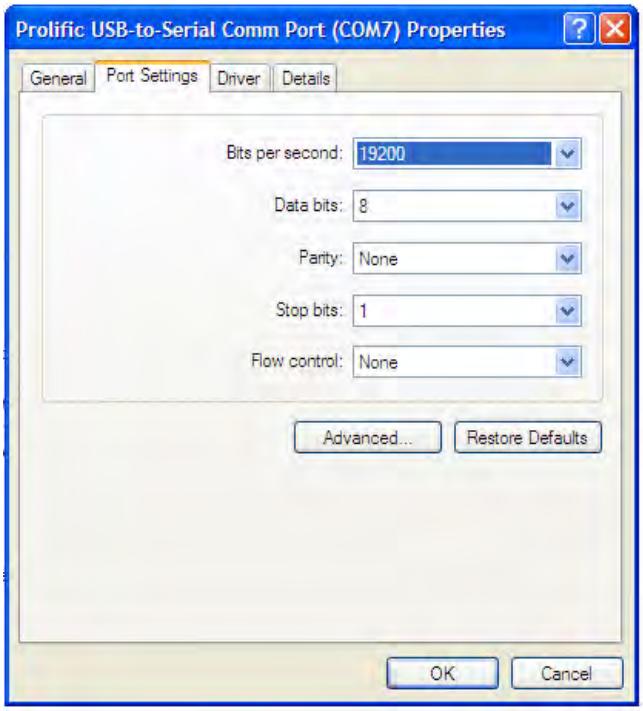

System Properties
System Restore
Automatic Updates
Remote
General
Computer Name
Hardware
Advanced
Device Manager
The Device Manager lists all the hardware devices installed on your computer. Use the Device Manager to change the properties of any device.
Device Manager
Drivers
Driver Signing lets you make sure that installed drivers are compatible with Windows. Windows Update lets you set up how Windows connects to Windows Update for drivers.
Driver Signing
Windows Update
Hardware Profiles
Hardware profiles provide a way for you to set up and store different hardware configurations.
Hardware Profiles
OK
Cancel
Apply




4. Go to ***Ports (COM & LPT)*** and press the "***+***" symbol to see ports:

- Go to ***Prolific USB-to-Serial Comm Port (COM7)***, right click and select ***Properties.***

- When on ***Prolific USB-to-Serial Comm Port (COM7) Properties*** windows appear, go to the tab "Port Settings" and make sure:



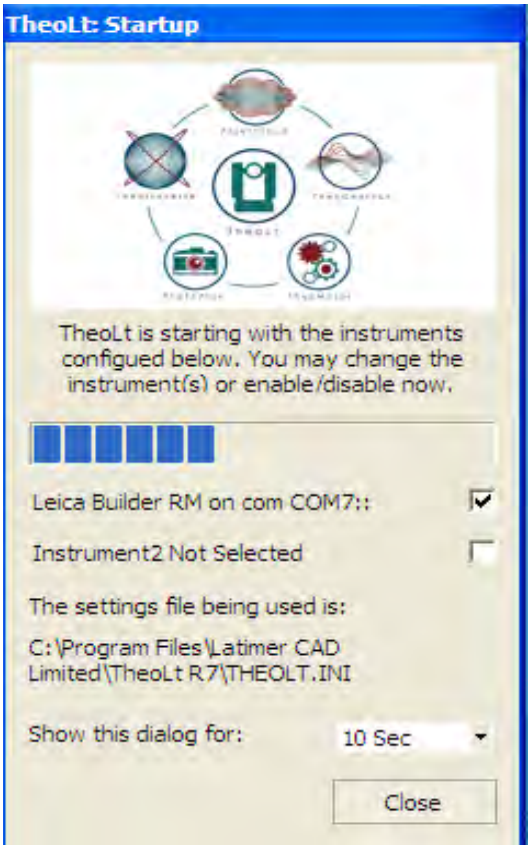

- Go to the ***Advanced*** button, here make sure that ***COM Port Number*** is set to ***COM7***

5. Press ***OK***

Advanced Settings for COM7
Use FIFO buffers (requires 16550 compatible UART)
Select lower settings to correct connection problems.
Select higher settings for faster performance.
Receive Buffer: Low (1) High (14) (14)
Transmit Buffer: Low (1) High (16) (16)
OK
Cancel
Defaults
COM Port Number: COM7

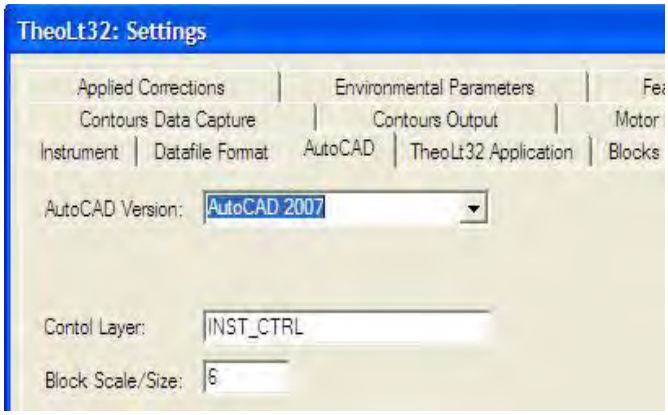
6. Now go to ***TheoltR7*** program

7. The ***Theolt: Startup*** will open and try to communicate with the Total Station, make sure the device is connected!, if it fails, your communications are not set correctly, do not worry yet and continue.

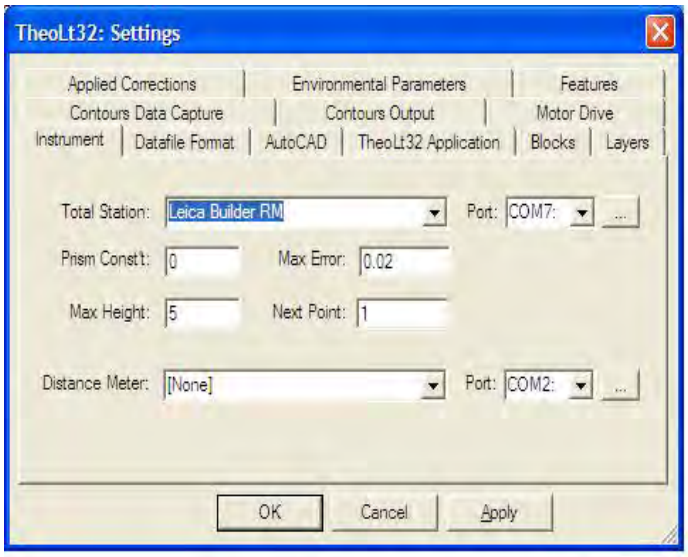

TheoLt: Startup
TheoLt is starting with the instruments configued below. You may change the instrument(s) or enable/disable now.
Leica Builder RM on com COM7::
Instrument2 Not Selected
The settings file being used is:
C:\Program Files\Latimer CAD Limited\TheoLt R7\THEOLT.INI
Show this dialog for: 10 Sec
Close

8. On the ***THeolt 7.0*** windows:

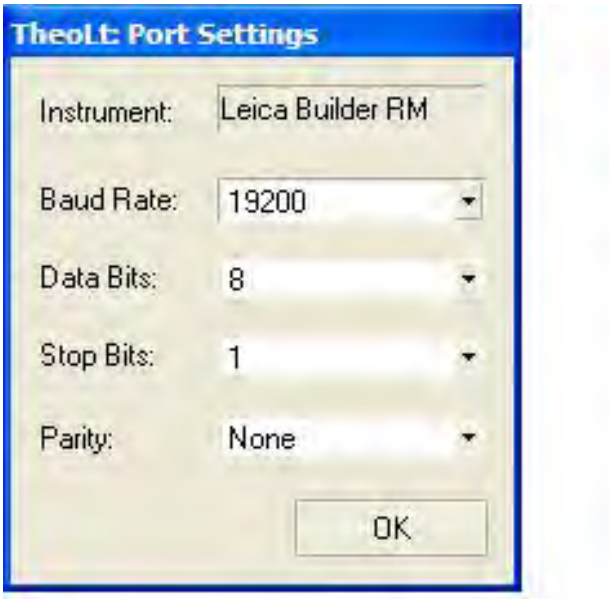
- Press the tab ***settings***
- Press the gray button on the right;
- When the ***Theoltt32: Settings*** windows appear: set the following parameters:
  a. On the AutoCAD tab: select your version on "AutoCAD version", in this case AutoCAD 2007;
  b. Set also the Block Scale to 3 so the ***instrument positions*** are smaller;




c. Now go to the ***Instrument*** tab > ***Total Station: Leica Builder RM*** >***Port: COM7*** and press "*....*"




d. When the ***Theolt: Port Settings*** appears, make sure:




9. ***Open*** Theolt again, now your instrument should be recognized.

# 3 Steps

### *Set-up Total Station*

***1. Take the tripod***, keep its legs together and loosen the clamping screws, let the legs drop out as you pull the stage up to your chin and retighten the clamping screws.

***2. Spread the legs*** open to form a stable shape. Place the feet so that they won't slip. Place the tripod approximately over the point. Placing your foot over the point and moving the tripod over your foot can help. Sight the point on the ground through the hole in the tripod stage and moving the whole assembly by rotation of 2 feet about the 3rd line the centre of the stage up with the point.

***3. Place the instrument*** carefully on the tripod. Check the tripod is stable, the stage roughly level and the plummet is over the point. Secure the instrument tribrach to the tripod with the central fixing screw. The screw should be tightened firmly.

***4. Drive the plummet*** to the centre of the mark with the tribrach foot-screws. Use 2 of the foot screws by turning your thumbs out or in together [but never turning them in the same direction] to move the plummet onto the point. The 3rd screw will provide the motion to move at right angles to the first movement.

5. With the plummet centred on the point the instrument is now levelled by adjustment of the tripod legs. Working on each leg in turn, slacken off the clamping screw and slide the leg to bring the instrument bubble in line with its centre circle. ***Retighten the clamping screw*** securely before adjusting the next. ***Measure and record the height of the instrument***.

***6. Switch on*** the Total Station by pressing the ***red button*** on the side and hold for 3 seconds;

***7. Wait***, the level should appear automatically, if this does not appear, go to:

- Using the upper yellow button press to tab "THEO", press the middle bottom under the screen "Level";

8. Make sure the ***red lower laser*** is directly on top of the "Instrument Position", this is done by elevating two legs with your hands and putting on top of the point;

9. Make sure that the ***instrument is in a comfortable height*** for you to reach and measure;

10. Now ***use the legs to level,*** using the upper water level, when the bubble reaches the center, the electronic level will be activated, now you can use the electronic level;

11. Before starting to work, make sure again that your lower laser is directly on top of the "Instrument position", if not move the device by unscrewing the Total Station in the tripod, be very careful, level again if needed;

12. When ready, press "OK".

13. Take the ***height of the instrument*** from the ground to the symbol under the Leica name on the side of the device, ***write down*** this number somewhere.

***When complete, the setup procedure must achieve three things, which are essential for measurements to work. If these conditions are not met the work will be imprecise and beyond repair!***

1. *STABLE AND SAFE,* clear from wet, dust, wind and traffic (foot, goats, vehicle or otherwise!) Make sure the instrument is clamped to the tribrach. Keep the tablet in the shade and never point the telescope into the sun

2. *VERTICALLY CENTERED OVER THE POINT.* If it's not over the mark don't use it!

3. *HORIZONTALLY LEVEL.* Keep an eye on the bubble, it will move off centre over time. Use the foot screws to bring it back to level, but don't forget if you adjust the level you will need to check the centring. Small adjustments can be made by carefully unscrewing the central mounting and sliding the tribrach back over the mark.

## *Measuring*

***To measure with the Total Station, make sure that your device is level and on top of the "instrument position" that you know the instrument height and that you have a "reference position".***

*- On the Total Station:*

1. Using the upper yellow button press to tab ***CONFIG***;

***2. VERY IMPORTANT:*** Make sure that the following settings are set on the Total Station:

- HZ Increment: Right
- V-Setting: Zenith

Otherwise, the measurements will be mirrored and wrong! (see page 61 of Chapter 6.2 on the "Leica Builder Series: User Manual");

3. Now to measure, still on the ***config*** tab, go down the page in the screen using the lower arrow until you reach ***Measure&Record***;

4. Select and with the side arrows select ***ALL-in-1*** option;

5. Now, using the upper yellow button press to tab "PROG", the middle button should show "***M & R***";

6. To set up the survey mode you need: either laser or prism, go to the yellow button with a black spot in the middle lower area of the device and press;

- If you want to measure with the laser (REDM):
  - On EDM Type: select ***red dot*** and press ***OK***
- If you want to measure using the prism:
  - On EDM Type and select with the arrows: ***prism***
  - On Prism Type: select ***TrueZero***
  - Press OK when done
- Always make sure that hr equals 0.000 m, this means that your prism height will be zero, since the height is control at Theolt, you do not need to set up this on the device.

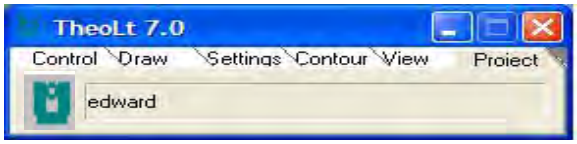
7. To measure, just press ***M & R*** under the tab ***PROG***

8. To switch on the ***laser pointer,*** press the black button on the side (we call it the "banana") for 2 seconds. Remember, having this on will consume your battery faster.

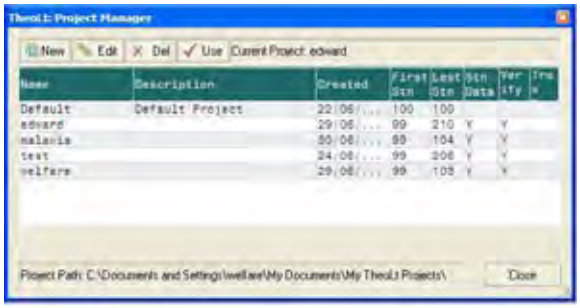
*- Setting up the local coordinate system on Theolt:*

1. Level and set up the Total Station on top of the first "***Instrument Position***", remember to mark instruments positions visible from your first position and covering the entire site you want to measure, you can use permanent pens and/or nails on the ground;

2. Go to the ***project*** tab and press the ***gray/ green icon***;




3. When the "***Theolt:project Manager***" appears, select "***New***"



4. When the Theolt: New Project windows appear:

- Project name: "your site name"
- Description: "your project description"
- Created by: "your name"
- Press OK

5. Now select your **new job** and press the icon "***Use***", press close, this is now your default project

*For the first time on site and to sep up a local coordinate system, use the following steps:*

6. Orientate the Total Station towards the magnetic north by using a Compass;

7. Go to the Control Tab and click the [***Orientation***] icon (gray icon on the far left);

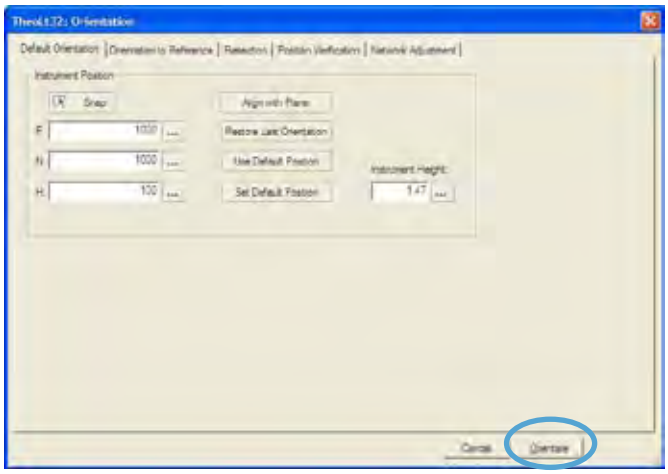
8. On the orientation menu go to the ´***Default Orientation***' tab, with the Total Station orientated to the North, type the "***Instrument height***" you have measured;

9. Type on:

- E: 1000
- N: 1000
- H: 1000

10. When you have oriented your machine towards the magnetic north, hit the button "***Use Default Position***";

11. Now press "***Orientate***", you are ready to work;



*To measure other instrument positions:*

12. First, measure your other "***instrument positions***" by:

13. Select the "***Control***" tab and make sure that "***Next Station***" number corresponds to your desired "instrument position" you want to measure, always start with 201;

14. Now measure with the Total Station, remember if you are measuring with the "Prism" to set the correct Prism height, this is done by going to the additional "***Instrument: Leica Builder RM***" window on the "***TH***" box, press the "check mark" and measure;

15. A windows "***Theolt: Control Type***" will appear hit "***Control Station (Fixed)***";

TheoLt: Control Type
Station Name: STA201
This is the first time this station has been referenced in this traverse. Please confirm whether the station is a control station or not.
Control Station (Fixed)
Unfixed Station

16. After this, a request for the status of the station may be prompted. The station should be declared as fixed.

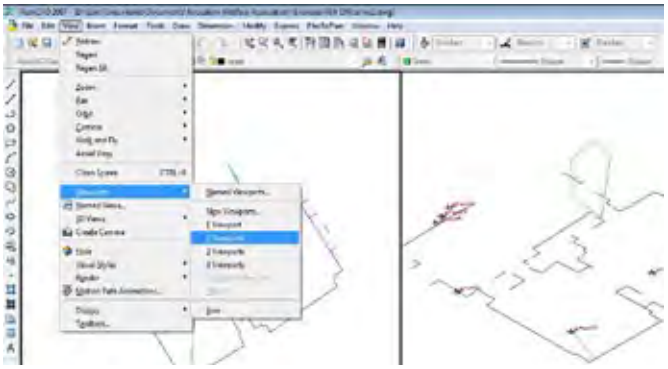
17. ***Measure*** all your instrument stations;

18. When finished, change to the tab "***Draw***" to start surveying the features.

## *Measuring features*

1. Make sure you are in the tab "***Draw***" on Theolt;

2. Split AutoCAD in two viewports: plan view and 3D view: go to ***view*** > ***viewports*** > ***2 viewports*** – on "***Enter a configuration option***": type: vertical;



3. With [***orbit***] command rotate the viewport to obtain a good 3D view of the part you are measuring;

4. Create the set of layers to carry out the survey in an organized way, split them by elevation orientations:

- Layers for controls (targets for rectified photography), ex. West_targets, East_ targets, etc;
- Layers for features (windows, doors, openings, etc), ex. West_features, East_ features, etc;
- Layers for cross sections: Cross_section_A, Cross_section_B, etc;

5. Select [***3Dpoly***] command and start measuring features:

- For targets, connect control points with 3D Polylines [***3Dpoly]*** or lines [***line***]. Draw the lines that are being surveyed on the printed photographs and/or sketches, this will allow you to understand back in the office the geometry you are creating with the sticker and/or natural targets;
- For other features, it is not needed to draw on the photos and sketches.

6. Save your file from time to time, use [***qsave***] command (For more information read page 34 - TheoLt r7.0.3 Reference Manual on Draw Tab).

### *AutoCAD tips for surveying with TheoLt*

1. Use viewports to see the whole and the part.

2. Use plan world to check the orientation has worked ok

3. Use layers to separate work by day, station, and surveyor.

4. Freeze off layers you don't need : it is always worth the time taken to get a clear view of where you are working

5. 3D views will let you keep a check on heights

6. Don't panic- TheoLt will always plot in the draw tab: if you can see the data from the instrument in the command line- provided you have a line command to catch the points!

7. Remember you can zoom in on detail and draw with a polyline snapped through the measured points to get smoother lines if needed.

8. Watch out for filedia it will need to be reset to 1 from time to time: use the customised 'F' button to re-set it when the saveas dialog fails.

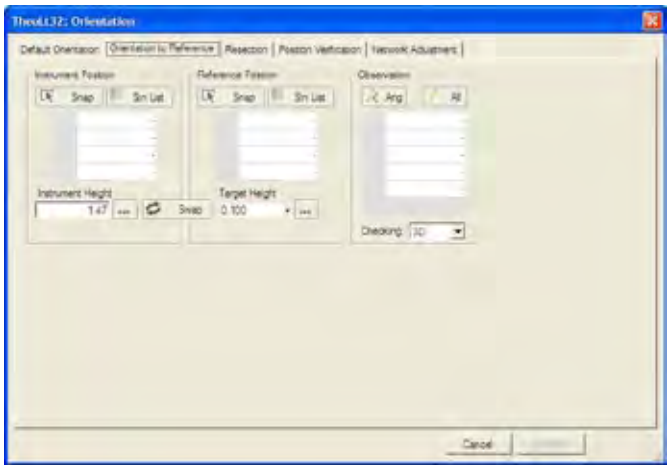
9. Remember to open your AutoCAD drawing before you open TheoLt: you won't be able to map anything without a drawing open!

## *Moving the Total Station around the building (inside and outside):*

Before moving the Total Station to a new position, you need to measure all you instrument positions, this manual explains how to use the "Orientation to Reference" feature built in Theolt to orientate your system.

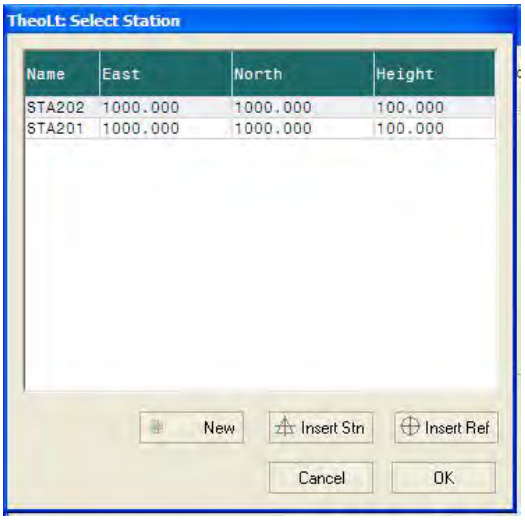
1. Go to the tab ***Control*** and hit the control ***icon***;

2. Go to the tab "***Orientation to Reference***";



3. Either "***snap to the point***", or easier go to the "***Stn List***" button on the Instrument Position and select where your device is leveled;

4. When the "***Theolt: Select Station"*** appears, select your position;




5. On windows "***Theolt: Station Instrument H.***" press OK

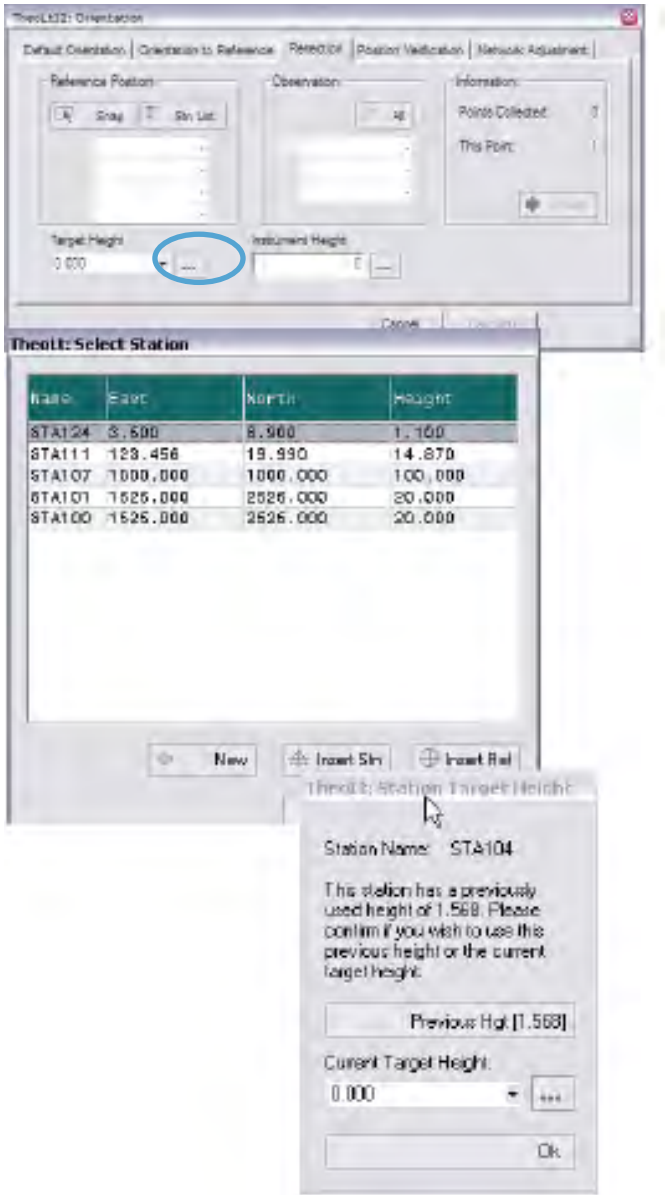
6. Insert the Instrument height that you have measured to the floor;

7. Go to ***Reference Position*** and either "***snap***" or "***Stn List***" to select the "***reference position***" you are planning to measure to orientate the Total Station;

8. Also remember to insert the "***Target Height***" in case you are using a prism;

9. Now press the "***M & R***" on the Total Station, information should appear on the "***Observation***" part of your "***Theolt32: Orientation***" windows. Press "***Orientate***", probably you will have an error windows with accuracy problems, this is caused by not carefully measuring the height of the instrument and measuring the "***instrument position***", if you are fine with the inaccuracy, just press OK and start surveying.

10. Remember to ***save your file*** and transfer it to a USB memory.




## *Using "Resection" to set up the Total Station:*

This feature of Theolt allows you to calculate the "instrument position" of your Total Station by measuring at least three known positions. Please read carefully and remember to measure these three "instrument positions" before you move to the "instrument position" you need to calculate. This process is very important when moving from one floor to another floor.

1. On Theolt go to "***control***" tab, select the [orientation] icon and select the "Resection" tab and go to the icon "***Stn List***" and from the pull-down menu select the control point (***station***) on the wall that you have measured, find this point with the Total Station and measure it;

2. Click on next, go to the icon "***Stn List***" and from the pull-down menu select the second control point (***station***) you measured before, find this point with the Total Station and measure it;

3. Click on next, go to the icon "***Stn List***" and from the ***pull-down menu*** select the second control point (station) you measured before, find this point with the Total Station and measure it. Now you are ready to calculate the new position where the Total Station is standing, select ***Calculate***, a new icon will appear on the drawing showing this new position, select ***close***;

4. Go to the ***Draw*** and continue measuring the features you need;

5. Repeat the ***resection*** approach any time you move. This will allow to link all the measurements to the same coordinate system;

6. Continue your ***survey***.

# 2. Scaled-rectified photography and CAD overlay

Scaled-rectified photography is a highly effective technique to generate a correct image-based representation of a fully or roughly flat plane; this tool can be used if the following conditions are available:

a. The surface should be flat, not irregular. Nevertheless, depending on needs, the recorder can use a certain degree of assumption about the irregularities of the surface.

b. The camera should be roughly or absolutely parallel to the surface to record.

c. An external reference system should be implemented to be able to acquire the scale of the object and reduce the distortion of the photograph.

d. Overlapping of at least 30% is required for recording the surface, if multiple photographs are being made.

The objective of rectified or plane-parallel photography is to produce a partial or absolute '*true-to-scale photographic image/print of an object such as the facade of a building*' (ICOMOS, 1990, p. 54)[1].

It is important to bear in mind that each regular plane should be rectified separately to cover the whole subject's fabric. This technique is executed in three phases of work: photo-acquisition, photo-rectification and photo-export.

Some scaled-rectified packages, as Imagemap, Photoplan and Asrix offer the possibility of rectifying images from real-time measurements taken with the Total Station under the CAD environment.

**NOT RECOMMENDED FOR**

Irregular surfaces - Circular surfaces

**Pros and Cons**

**Benefits**

Quick and reliable technique to record elevations
Requires a relatively minimal investment
Advanced surveying expertise is not required
Best suited for CAD overlay (digitizing surfaces)

**Constraints**

Only works with relatively regular surfaces
Limited to single surfaces
Requires good photography and accurate controls
Work intensive when vectoring photographs

Figure 1: not recommended surfaces for scaled-rectified photography

# a. Principles

### *Different planes*

A building façade is usually composed of different planes (main facade, balcony, cornice, roof, etc ). Please bear in mind that when using scaled-rectified photography, only an orthogonal projection[2] of a single plane is rectified. If needed, measure five controls of each plane to be rectified, you will need to produce a rectified image for each of those planes measured. Figure 2 illustrates the different planes in a step pyramid; here each plane has five controls, which are measured to produce an appropriate orthographic projection of the elevation of this subject.

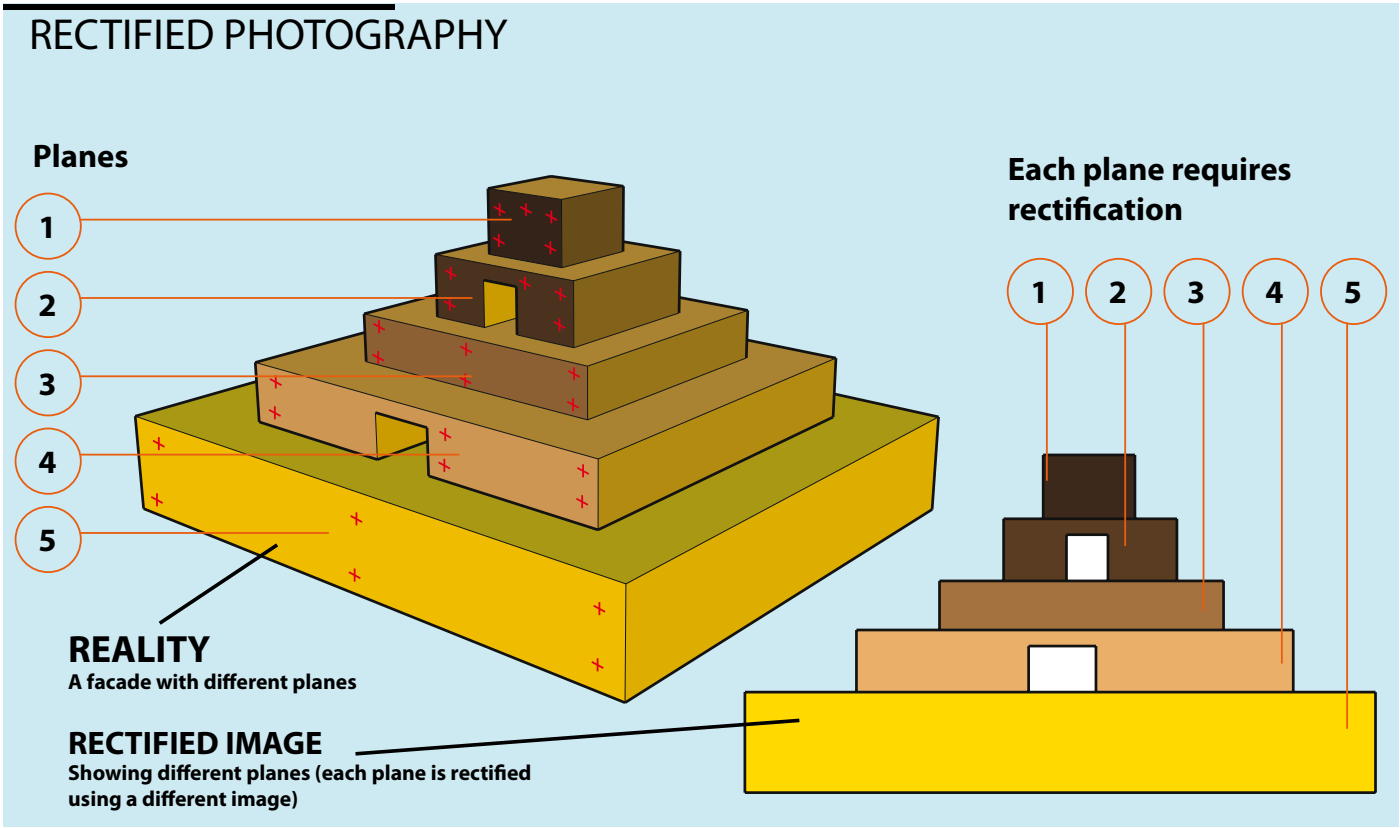



Figure 2: planes in scaled-rectified photography

### *Camera distortion*

Scaled-rectified photography is a very useful technique to record regular surfaces. However, it is important to understand that photography is affected by radial and perspective distortions, as figure 3 shows.

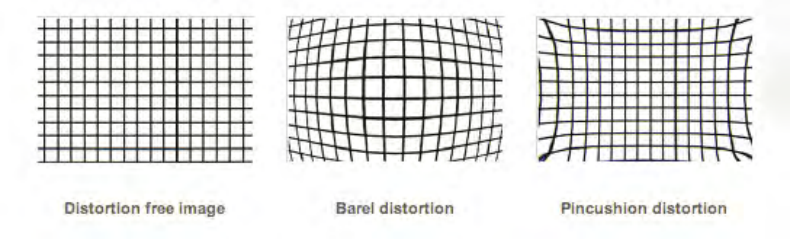
Radial distortion is present in all camera lenses, in terms of this manual, its reduction will be carried out by means of the scaled-rectified software. It is important to be aware that surveyors specialized in this type of survey use specialized software to understand the distortion parameters of a lens, called camera calibration.

Figure 4 illustrates how a leveled and parallel photograph to the plane is taken to reduce perspective distortion, however in most cases, this type of distortion is difficult to overcome, as the distance to the subject is little and the leveled camera would not capture the entire elevation. For this reason, in many cases the camera is tilted. The specialized software explained in this manual will systematically reduce the perspective distortion.

## IMAGE ISSUES

Issues affecting photography as a metric survey tool:

**Radial distortion** is a failure of a lens to be rectilinear: a failure to image lines into lines. If a photograph is not taken straight-on then, even with a perfect rectilinear lens, rectangles will appear as trapezoids: lines are imaged as lines, but the angles between them are not preserved (tilt is not a conformal map). This effect can be controlled by using a perspective control lens, or corrected in postprocessing



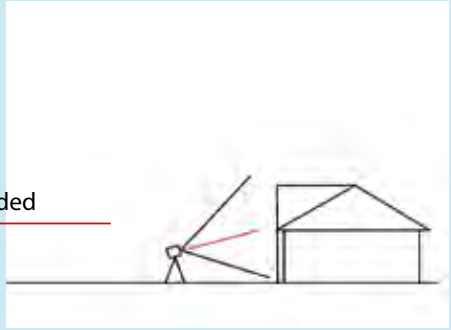

**Perspective distortion** is a warping or transformation of an object and its surrounding area that differs significantly from what the object would look like with a normal focal length. Perspective distortion can typically be seen in images shot using a wide angle of view, where an object close to the lens appears abnormally large relative to more distant objects, or in distant shots with a narrow angle of view, where the viewer cannot discern relative distances between distant objects and more distant objects may look exceptionally large, when such images are

http://en.wikipedia.org/wiki/Distortion_(optics) - http://en.wikipedia.org/wiki/Perspective_distortion_(photography)
http://www.dxo.com/us/photo/dxo_optics_pro/optics_geometry_corrections/distortion

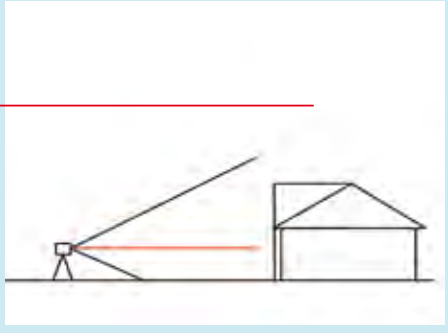
Figure 3: issues affecting rectified photography: radial and perspective distortion

## Reducing perspective distortion

Vertical tilt of camera is not recommended



Optimal position



Slide courtesy of Christian Ouimet, Public Works Canada

Figure 4: reducing perspective distortion

The "Dimensional Field of View Calculator" on the website http://www.tawbaware.com/maxlyons/calc.htm (accessed 13/09/2010) provides an idea of the distance to the subject required with a specific 35mm camera (and lens).
For more information please read page 11-13 of Measured and Drawn book by English Heritage, which is included in the reference DVD.

# b. Recording methodology

This manual describes a four-step methodology to produce a scaled-rectified photography for recording building elevations (interior and exterior). Please bear in mind that the subject should be relatively flat and this technique is scale-dependent. A photograph should show enough detail to be able to digitize high level of detail of the building's texture quickly. Figure 5 illustrates the process.

The manual does not cover "CAD overlay" of rectified photographs, as this is a procedure that should be developed by the institution.

It is important to bear in mind that rectified photography is a very useful technique, when it is applied on regular surfaces. Scale and level of detail will dictate the quality of the photography required.

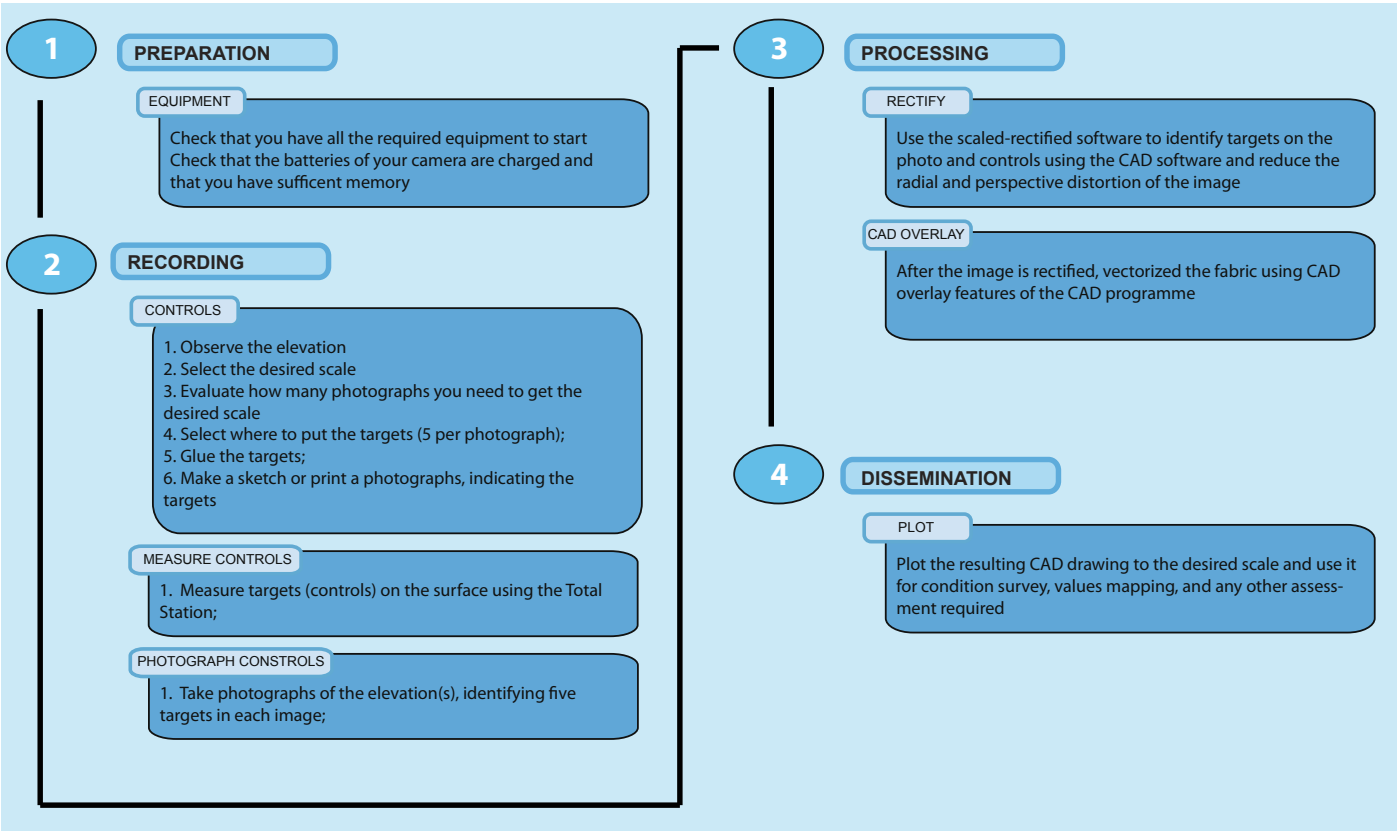

1
PREPARATION
EQUIPMENT
Check that you have all the required equipment to start
Check that the batteries of your camera are charged and that you have sufficent memory
2
RECORDING
CONTROLS
1. Observe the elevation
2. Select the desired scale
3. Evaluate how many photographs you need to get the desired scale
4. Select where to put the targets (5 per photograph);
5. Glue the targets;
6. Make a sketch or print a photographs, indicating the targets
MEASURE CONTROLS
1. Measure targets (controls) on the surface using the Total Station;
PHOTOGRAPH CONSTROLS
1. Take photographs of the elevation(s), identifying five targets in each image;
3
PROCESSING
RECTIFY
Use the scaled-rectified software to identify targets on the photo and controls using the CAD software and reduce the radial and perspective distortion of the image
CAD OVERLAY
After the image is rectified, vectorized the fabric using CAD overlay features of the CAD programme
4
DISSEMINATION
PLOT
Plot the resulting CAD drawing to the desired scale and use it for condition survey, values mapping, and any other assessment required

Figure 5: recording methodology

# c. Manual

## 1 Preparation: required tools:

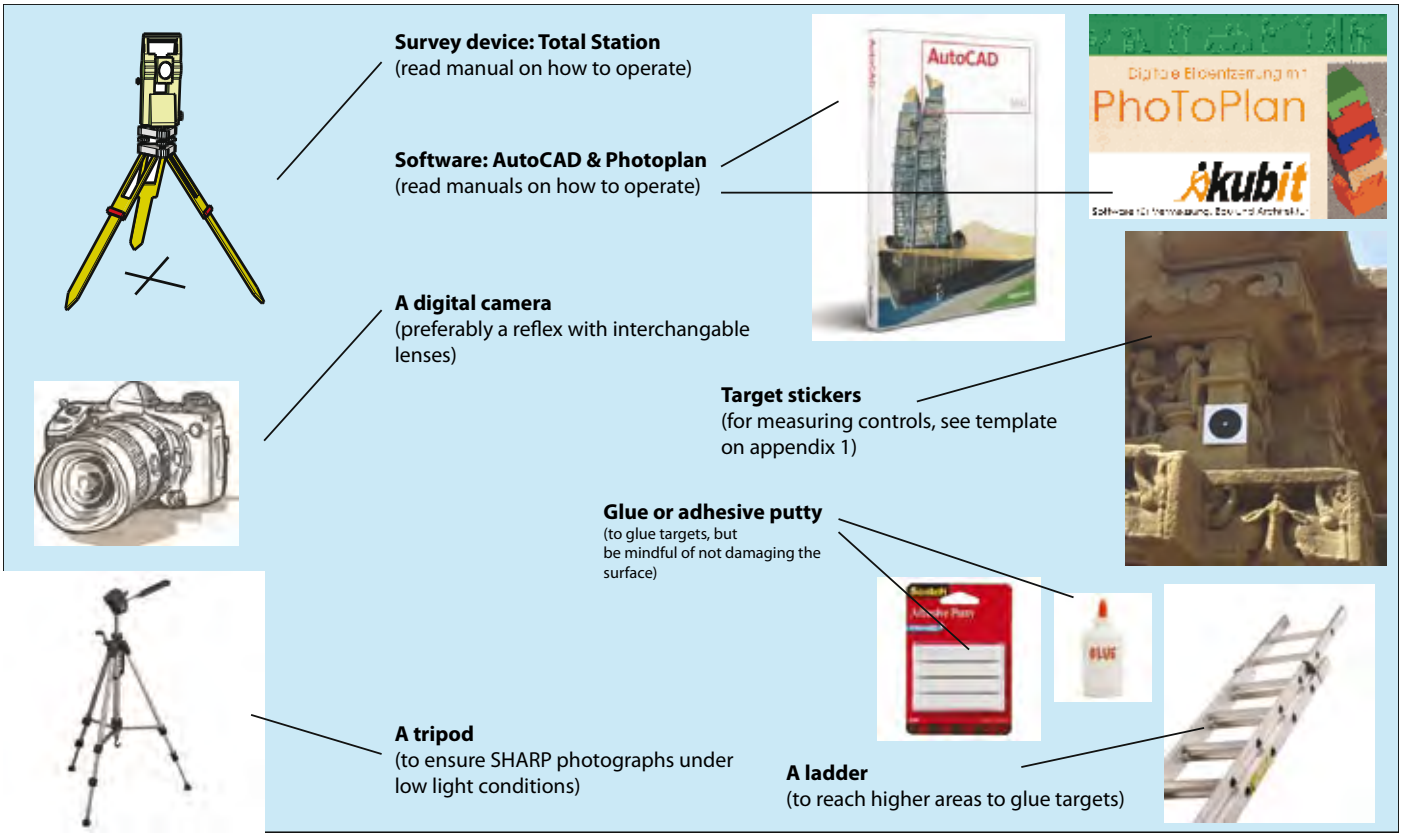

Survey device: Total Station
(read manual on how to operate)
Software: AutoCAD & Photoplan
(read manuals on how to operate)
AutoCAD
PhoToPlan
kubit
A digital camera
(preferably a reflex with interchangable lenses)
Target stickers
(for measuring controls, see template on appendix 1)
Glue or adhesive putty
(to glue targets, but be mindful of not damaging the surface)
GLUE
A tripod
(to ensure SHARP photographs under low light conditions)
A ladder
(to reach higher areas to glue targets)

Figure 3: equipment needed for scale-rectified photography

### *Competences (or skills) required*

In order to be effective in the preparation of rectified photography and CAD overlay, the recording team should have:

a. -Knowledge of recording and production of measured drawings of heritage places;
b. Advanced knowledge in the operation of a REDM Total Station;
c. -Knowledge of AutoCAD: basic notions of 3D and advanced notions of 2D drawing.

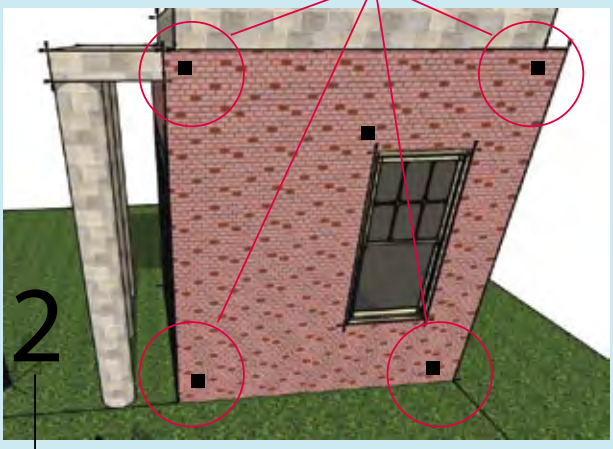
In terms of the survey, please be mindful of the fabric of the heritage place to be recorded, as the use of stickers (for targets) might affect the integrity of the surface. Use only removable glue or adhesive putty. Eventually a good printed photograph of the subject can provide sufficient detail to record "natural features of the building" instead of gluing targets.

Also, mind your own safety when gluing targets into higher areas of the subject. It is preferable that the recording team ensures safety equipment and measures when using ladders or scaffolding.

## RECORDING: SELECT SCALE, NUMBER OF PHOTOS AND GLUE THE TARGETS

A. Observe the elevation
B. Select the desired scale
C. Evaluate how many photographs you need to get the desired scale
D. Select where to put the targets (5 per photograph/plane);

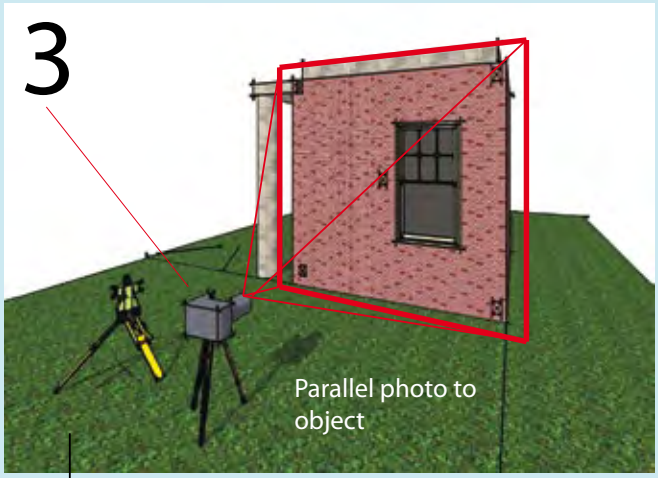
Glue the targets on the upper/bottom corners of the subject to obtain a better rectified image covering the entire plane



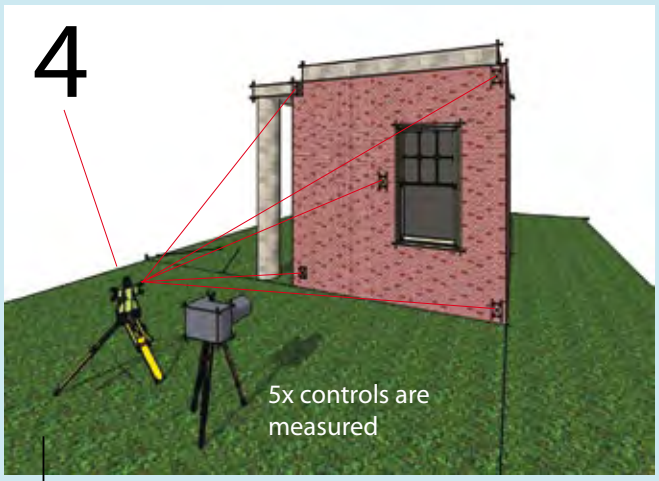

A. Glue the targets (do not damage the subject's fabric);
B. Make a sketch or print out a photograph indicating the location of the targets

Figure 4: recording approach: steps 1 and 2

## RECORDING: PHOTOGRAPHING THE SUBJECT AND SURVEYING CONTROLS




Take a photo parallel to the subject (plane: facade)




Use the total station to record the position of the 5 control points

Figure 5: recording approach: steps 2 and 3

# 3 Processing: rectifying the images

## *Preparation at the office*

- Please follow the instructions in the Photoplan manual to install this plug-in on your PC and AutoCAD, read pages 3-1 to 3-5[3].
- Plug the USB Hardware key into a USB port on your computer;
- Open AutoCAD;
- Open your surveyed drawing, resulted from the measurement of the targets using lines (or 3D polylines);

## *Making a UCS corresponding to the elevation to rectify:*

- Create a layer UCL and make it default;
- Use Polyline command, type PL on the command line (see Figure 6: a);
- Go to the bottom left target and snap;
- Go to the bottom right target and snap, press enter, this will make a perfectly horizontal line between these two targets;
- Now, using the "line" command, type l on the command line and snap on the bottom left target ;
- Type @0,0,5 and press enter, this will make a vertical line (see Figure 6: b & c);
- Now type in the command line UCS;
- For specify origin of UCS or (.... > Type 3P;
- Now snap the bottom left corner of the polyline (see Figure 6: d);
- Now snap on the bottom right (endpoint) of the polyline (not of the target);
- Now snap on the upper right point of your line drawn before;

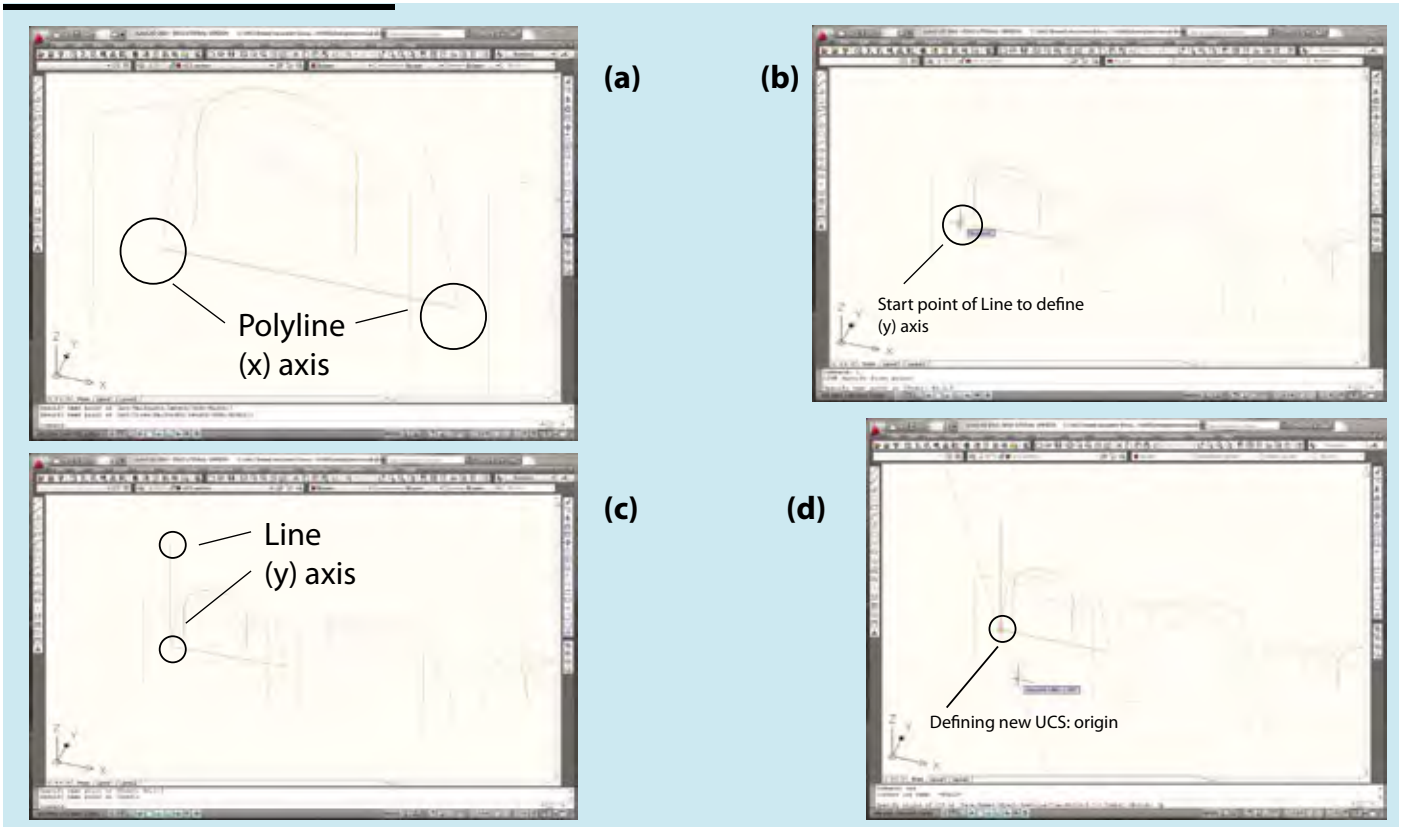



Figure 6: defining a UCS with the geometry of the target measured with the Total Station in AutoCAD

- To save this new UCS, type on the command line DDUCS;
- For the "Named UCS" window select the Unnamed and change it to the elevation name you have defined, for example Elevation, hit "Set Current" and follow with OK (See Figure 7: a - b);
- Freeze now all the layers except your target layer;
- Make a parallel view to the new UCS defined by going to view > 3D Views > Plan View > Current UCS (See Figure 7: c and d);

You have created a projected view of your elevation.

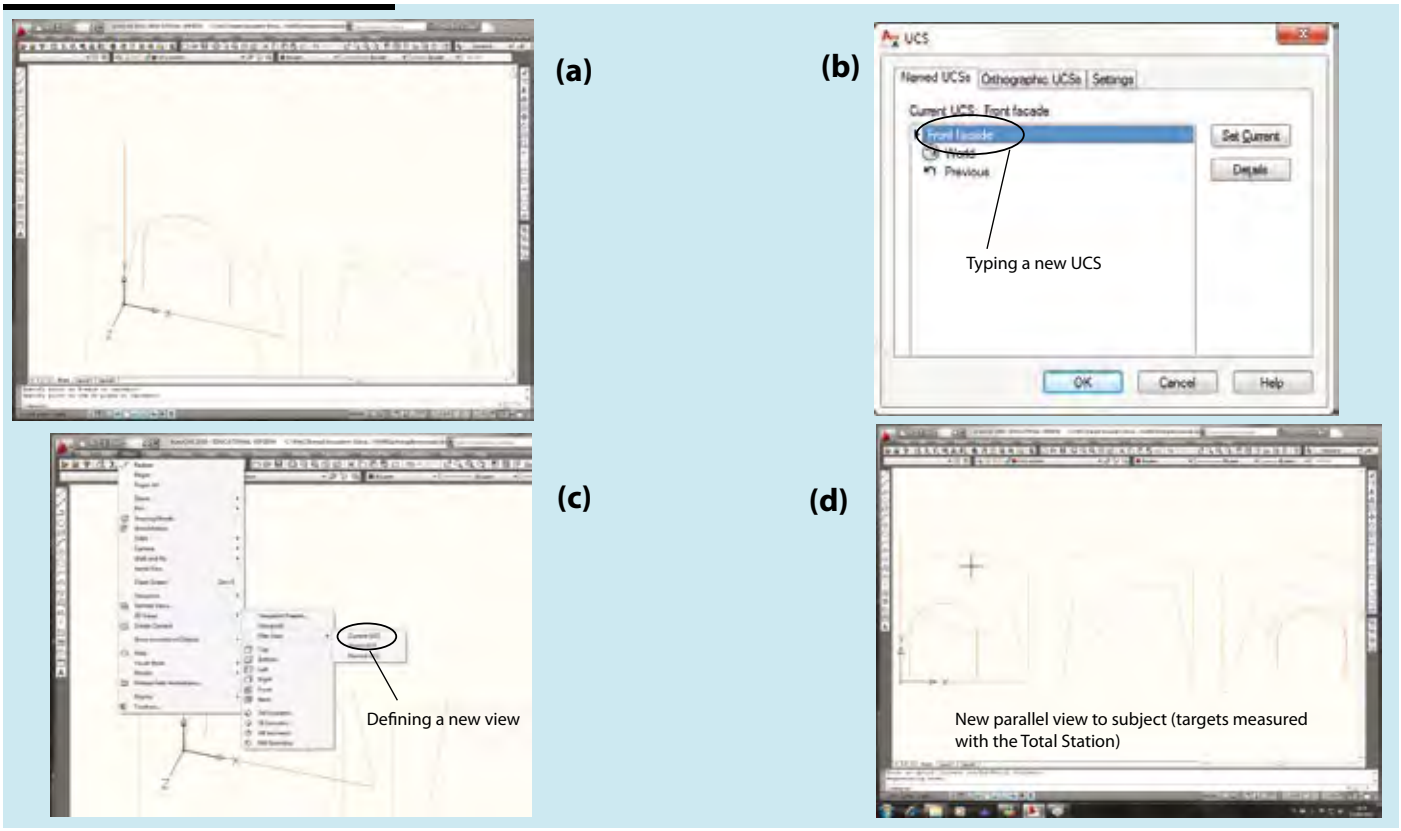



Figure 7: defining a UCS with the geometry of the target measured with the Total Station in AutoCAD

To save this orthogonal projection view that has been defined:

- Type DDVIEW on the command line and hit enter;
- Hit "New" on the "View Manager" windows;
- On the "new view / Shot Properties" windows type the name of your view on "View name", and hit ok;
- Back on the "View Manager" windows hit "apply" and Ok;
- If you want to return to the parallel view defined, just type again "DDVIEW" on the Command Line, and on the "View Manager" windows select under "Model views" the name of the view and hit "Set Current" and apply;
- To exit hit Ok;

## *Making a scaled-rectified image*

Important: please read the Photoplan manual about "Tutorial 1 – Your first photo rectification according to control points" on pages 5-2 to 5-8" to understand the process to follow.

After defining your UCS and new projected view of the elevation:

- Go to Photoplan> control points > Define control points
- When the windows "Define control points (s)" appears, hit pick point and snap on the target, back in the "Define control points (s)" pick (snap) the remaining targets, when you have finished hit "close" (See Figure 8: a - b);
- Go to Photoplan> Image > Load image and browse for the distorted image of your elevation, hit open;
- Now place it next to your control points (See Figure 8: c)
- Go to Photoplan> Image rectification by control points > Rectification of Photos (Projective Transformation)
- Press "New" and select the distorted image (See Figure 8: d);

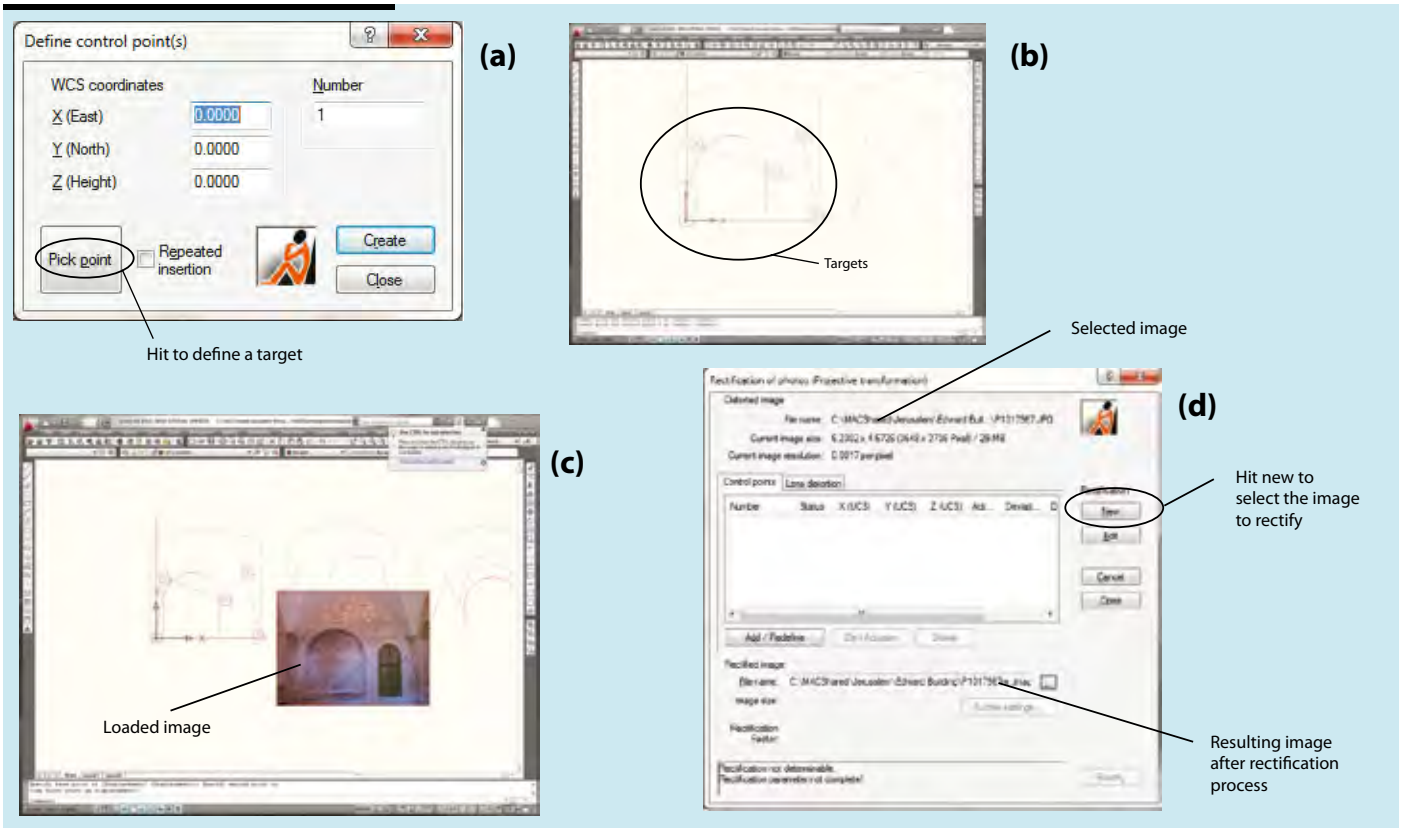



Figure 8: photoplan: rectifying images

- Back in the "Rectification of Photos" windows, now go to "Add / Redefine" button (See Figure 8: d);
- When back in Autocad, select the control point, zoom into the area where this control point is on the distorted image and pick with the mouse (See Figure 9: a - b);
- Continue doing this process with all the control points, when finished, press enter;
- Back in the "Rectification of Photos" windows, go to File name and hit the ... button next, browse and give a name to the resulting rectified image (See Figure 9: c);
- Check the accuracy of your control points by looking at the deviation column, if everything is according to the desired accuracy, hit "Rectify". You can alternatively select a "control point" with less accuracy and hit (DE-) Activate (See Figure 9: c);
- Hit Rectify and look at your image (See Figure 9: c);
- Now your rectified image should appear on the correct position (See Figure 9: d);

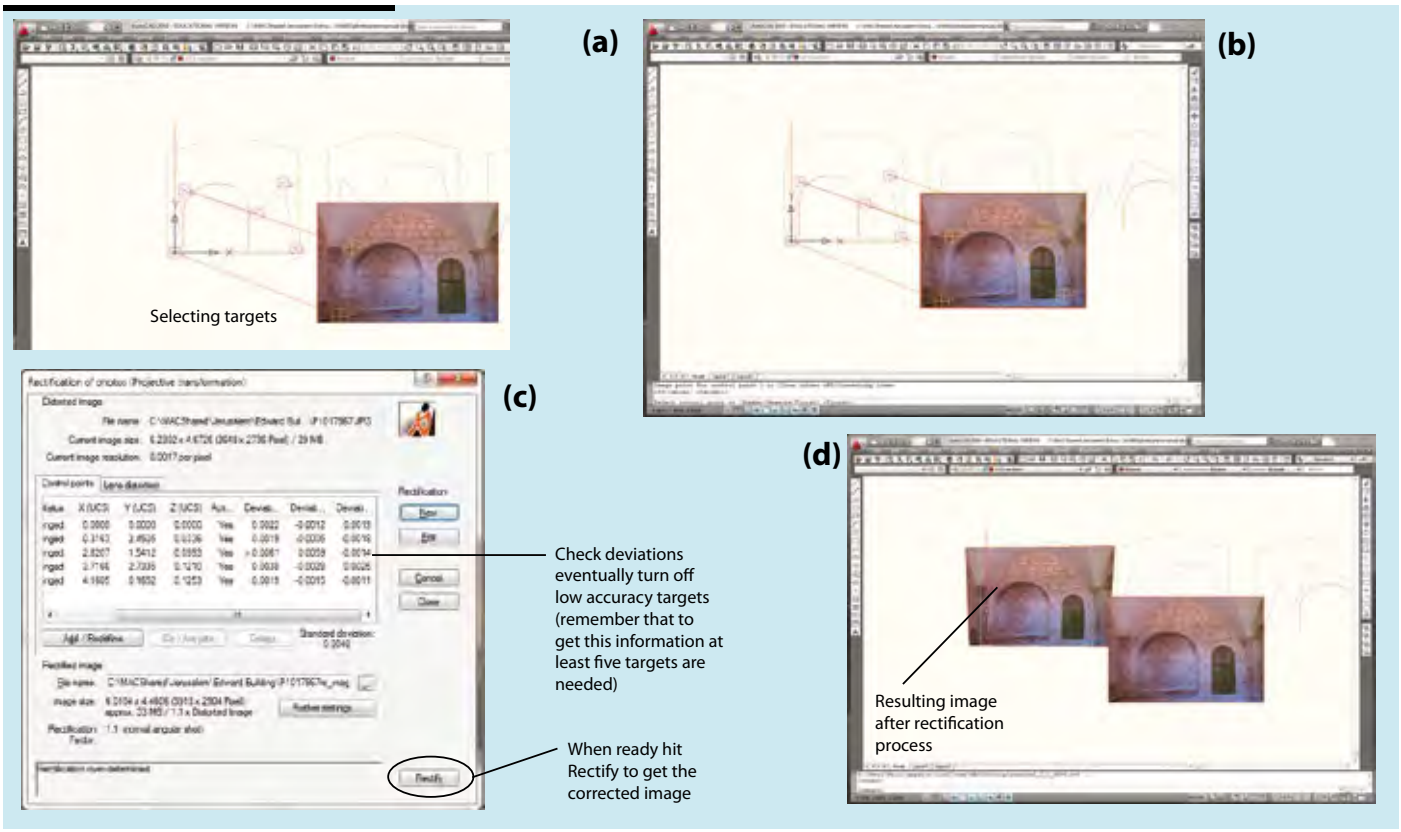

(a)
Selecting targets
(b)
(c)
Check deviations eventually turn off low accuracy targets (remember that to get this information at least five targets are needed)
When ready hit Rectify to get the corrected image
(d)
Resulting image after rectification process

Figure 9: photoplan: rectifying images

- You can now click to hide areas which are not rectified. This is done by drawing a polyline around the rectified areas and closing the line (See Figure 10: a -b);
- Now go to Photoplan > image > Clip image
- Select the image to clip;
- Select the polyline you just drew
- Press enter, and on the Photoplan: Delete used polylines ?, clip Yes (See Figure 10: c);

Now you can draw on top of the image to prepare a CAD overlay of that elevation.

- To CAD overlay a rectified image, just define a layer and vectorized the fabric using polyline or lines (See Figure 10: d);
- Examples of CAD overlayed rectified photographs can be found in Appendix 2.

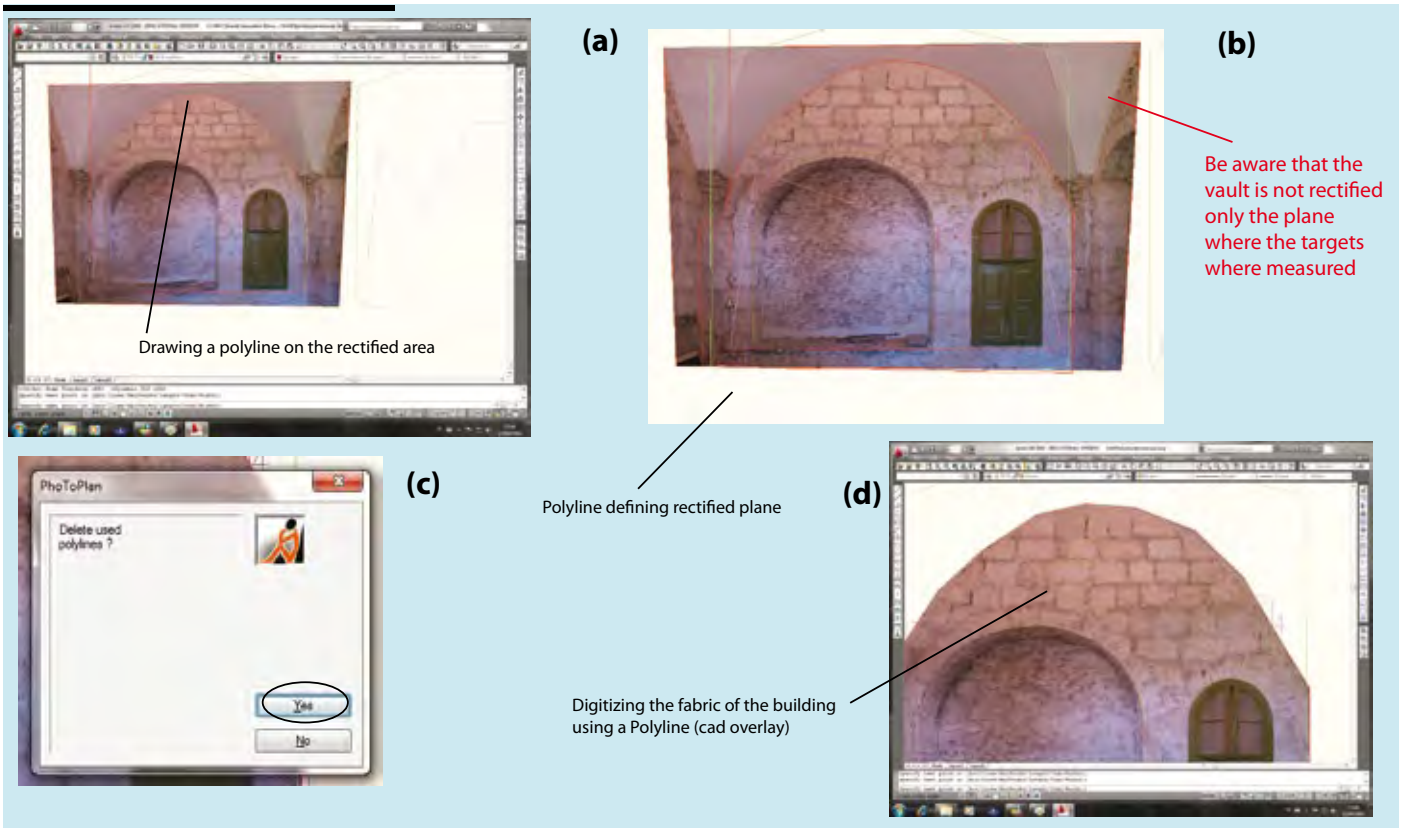

(a)
(b)
Drawing a polyline on the rectified area
Be aware that the vault is not rectified only the plane where the targets where measured
PhoToPlan
Delete used polylines ?
Yes
No
(c)
Polyline defining rectified plane
(d)
Digitizing the fabric of the building using a Polyline (cad overlay)

Figure 10: photoplan: clipping rectified images

## *Further References*

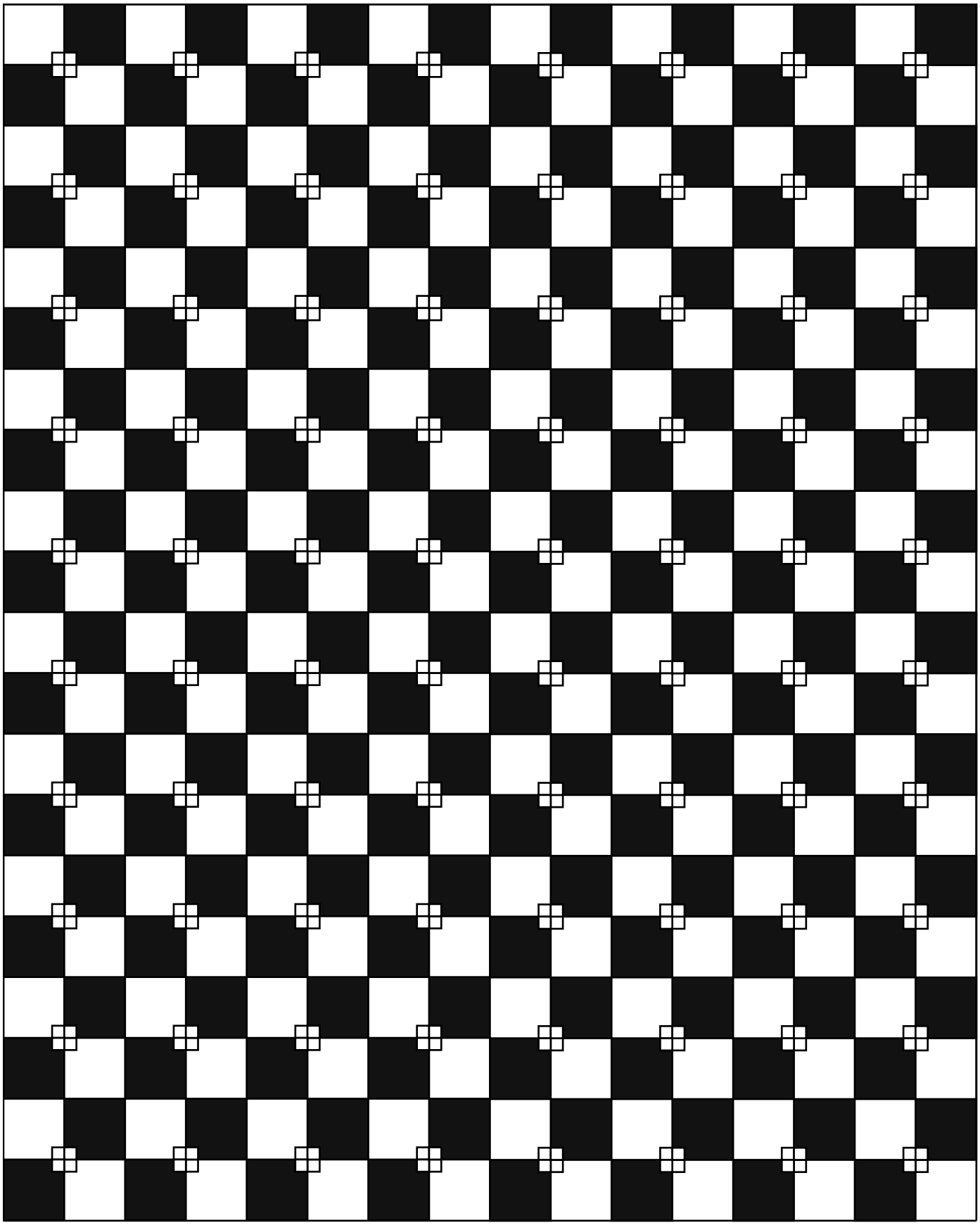

- Andrews, D., Blake, B. Cromvell, T. "Measured and Drawn: Techniques and Practice for the Metric Survey of Historic Buildings", English Heritage; 2nd edition (2004). http://www.english-heritage.org.uk/publications/measured-and-drawn/measured-and-drawn.pdf/ (accessed: 20/08/2010)
- Brennan, J. "Rectified Photography" http://www.buildingconservation.com/articles/rectified/rectified.htm (accessed: 20/08/2010)
- Santana Quintero, M. The Use of 3D Documentation and Dissemination Techniques in Studying Built Heritage, PhD related to the use of 3D Metric survey techniques in studying cultural heritage: http://www.3darchdoc.com/phd/ accessed 20/08/2010

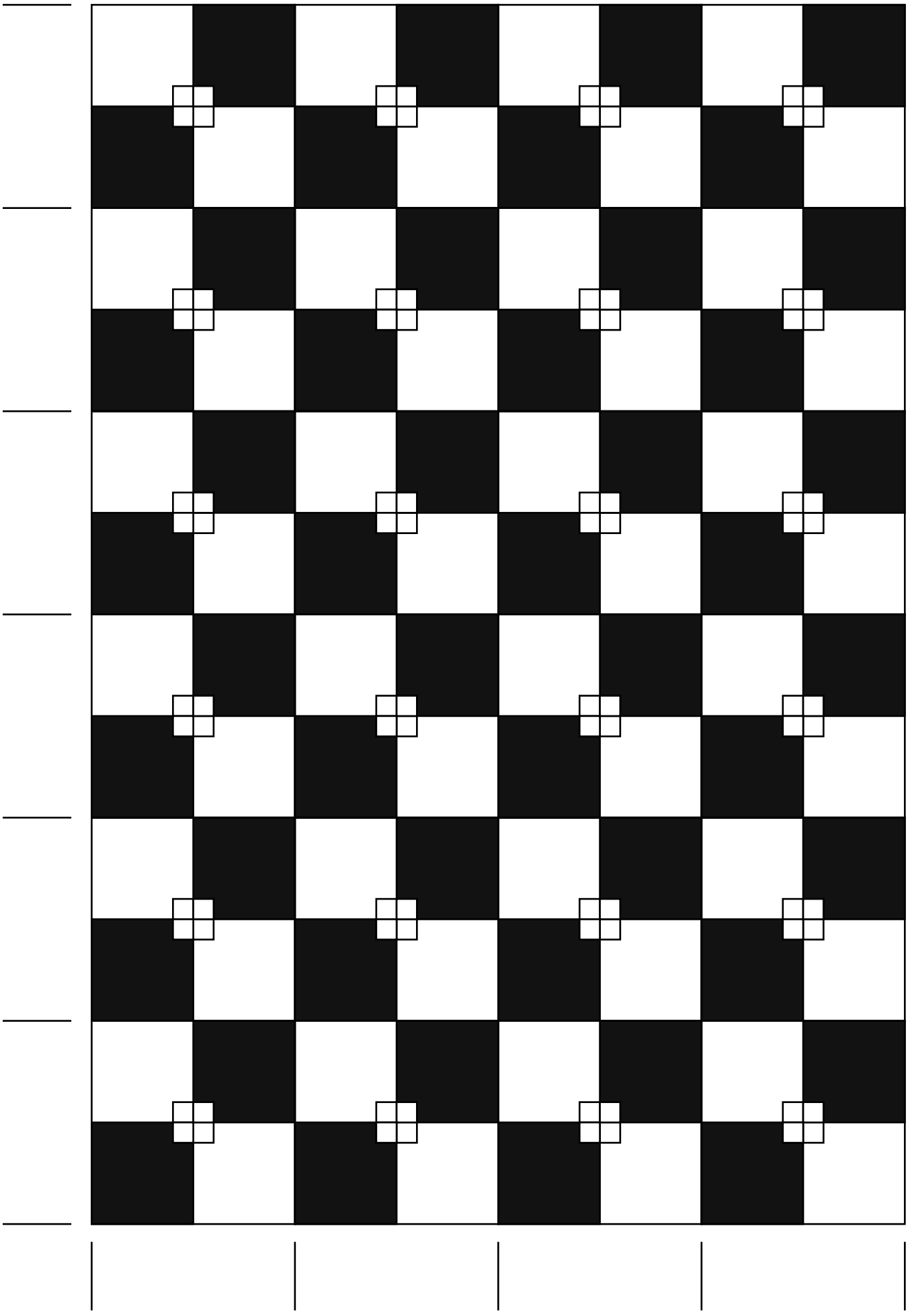

## *Endnotes*

1. ICOMOS; Guide to Recording Historic Buildings; Butterworth Architecture, London 1990. P. 54.
2. Orthographic projection is the method of showing solid objects, which are actually three-dimensional, in two-dimensional drawings by means of related views called plans, elevations, and sections. Most drawings of buildings are of this nature. Reekie, F. "Reekie's Architectural drawing", Architectural Press, 4th edition, Oxford 1988, p. 46.
3. PhoToPlan: Measuring within photographs Manual (PhoToPlan 6.0), Kubit (2010), pp. 3-1 – 3-5

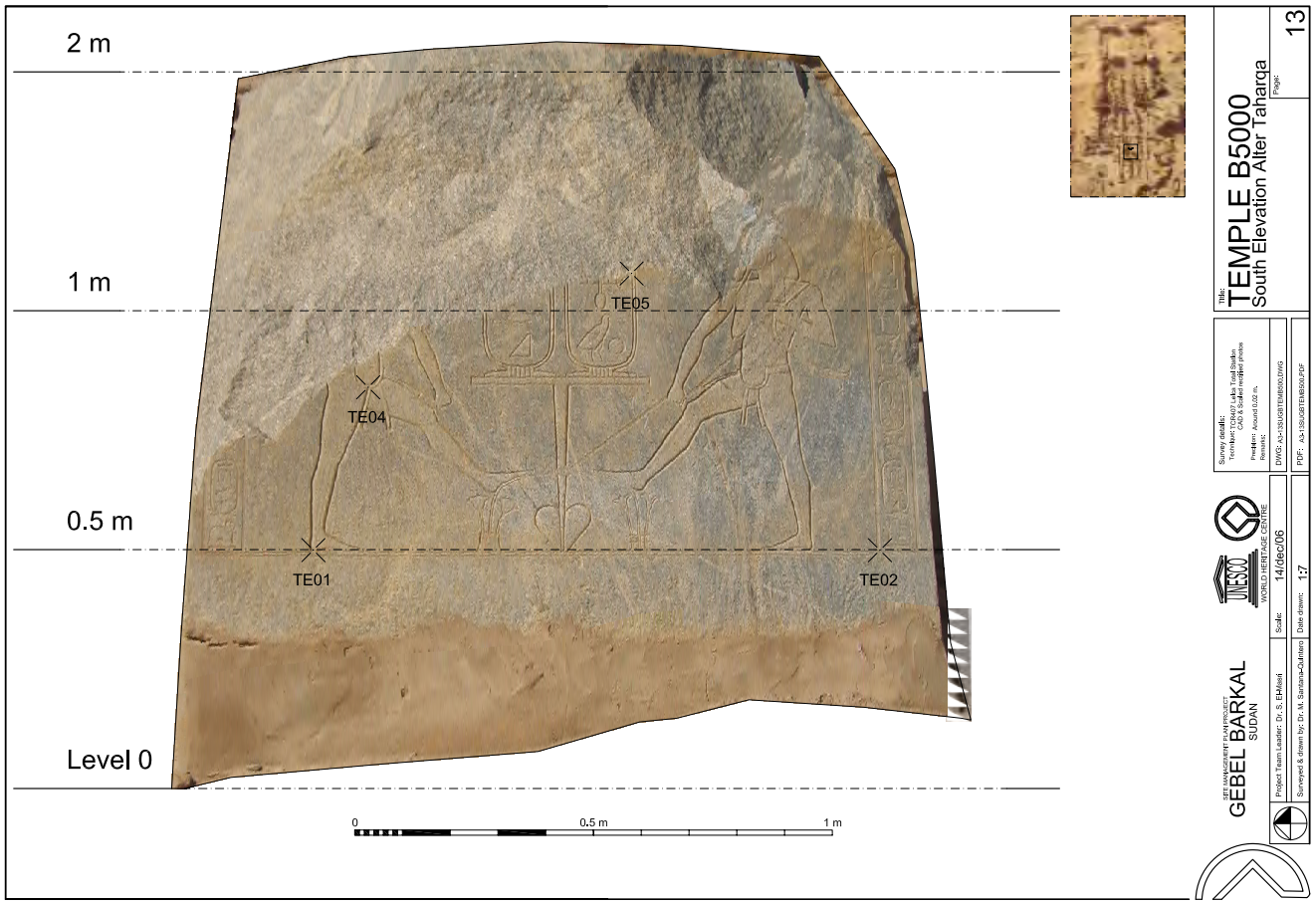
# d. Appendix

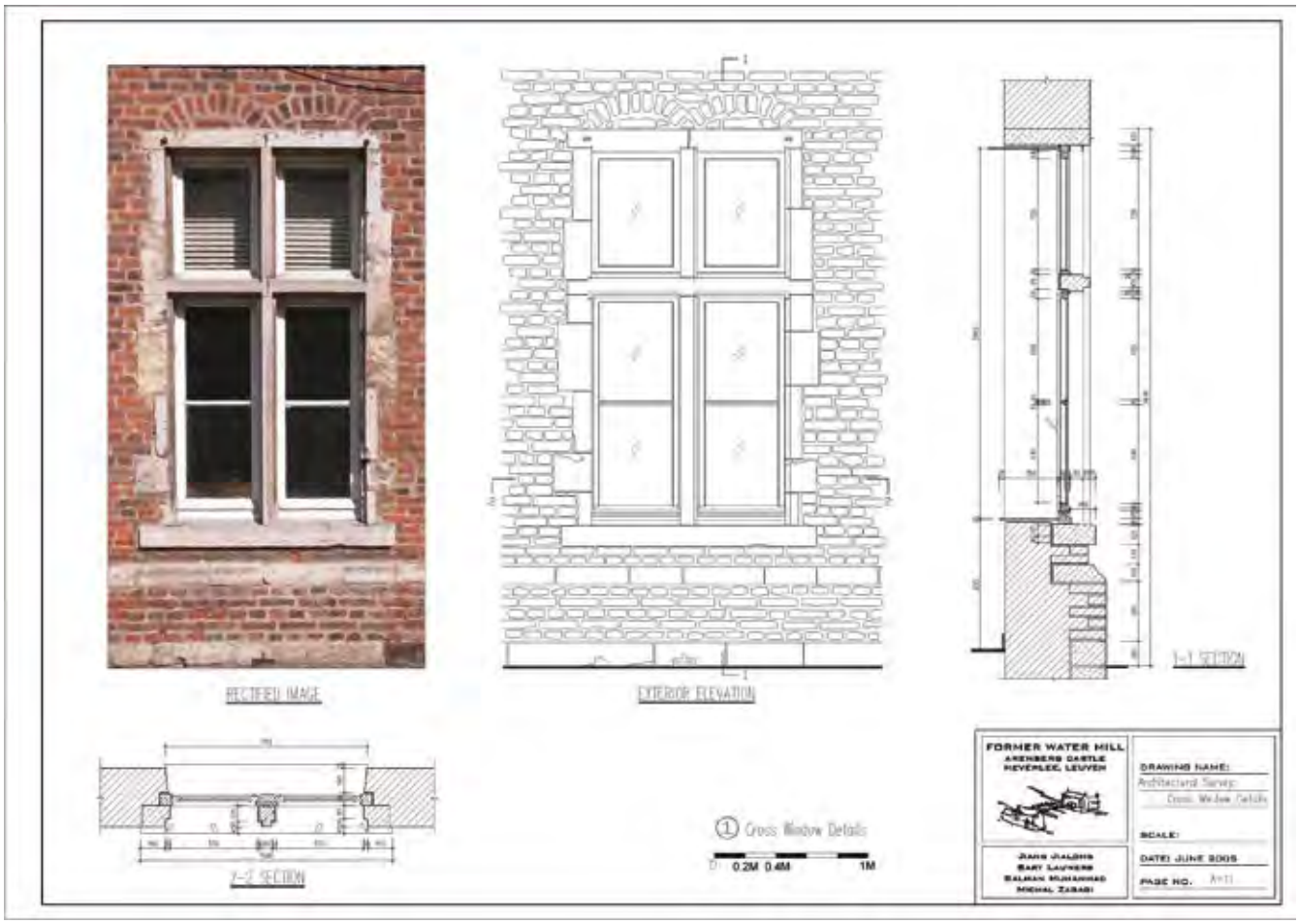
***APPENDIX 1: Small tragets***





## *APPENDIX 3: Example of Rectified Images*



# 3. Geographic Information Systems

## a. Most Used Toolbar

**New Map File:** make a new project

**Open:** open an existing ArcMap-project (*.mxd)

**Save:** save as an ArcMap-project (*.mxd)

**Print**

**Cut**

**Copy**

**Paste**

**Delete**

**Undo/redo**

**Add data:** maps or tables adding into the project

**Map Scale:** change scale of the view

**Editor Toolbar**

**ArcCatalog:** kind of explorer

**What's this?:** Help function

**Zoom in / Zoom out:**

**Dynamic zooming**
**Fixed zoom in / Fixed zoom out:**

**Pan:**

**Zoom to full extent**

**Previous / Next Extent:**
Back to previous zoom level

**Select Features:** selected features become blue

**Select Elements:** Standard cursor

**Identify:** shows attributes

**Find:** finds objects by giving their attributes

**Measure:** distance measurement

**Hyperlink**: opens a hyperlink

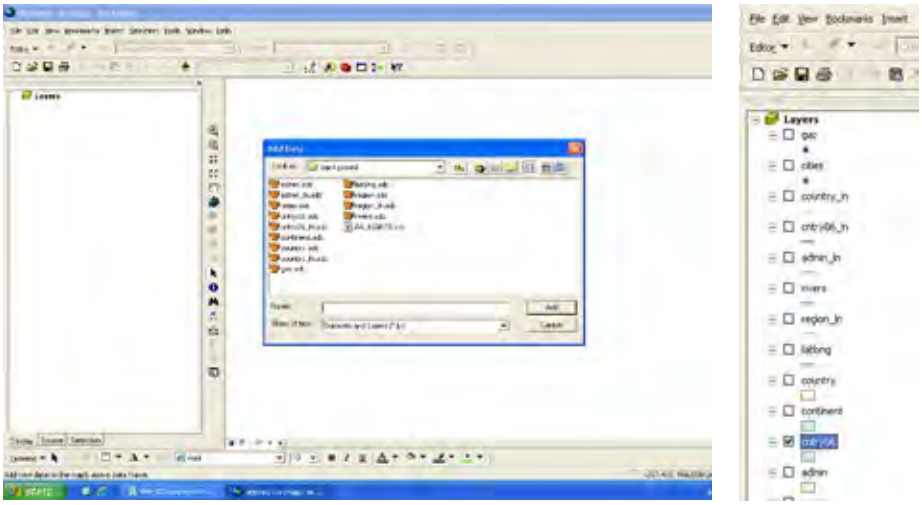
If the toolbar disappears: RCL in the upper part of the toolbar in the grey zone and select "tools"
DCL = double click RCL = right click

# b. Where is... What is...

***Data: "background"***

1. Load all data from the map "background" The order of the themes in the Table of Content (TOC) is polygons, lines and points.

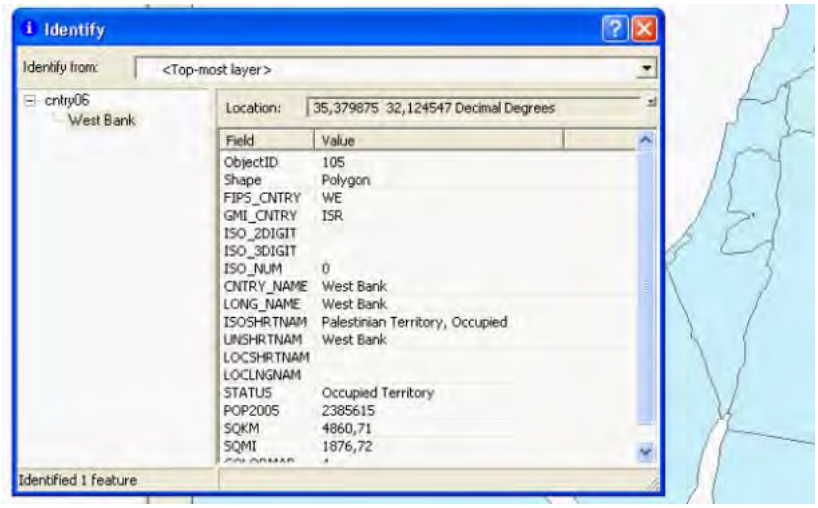
2. Deselect all the boxes in the TOC.



3. Check the box of theme "cntry06"

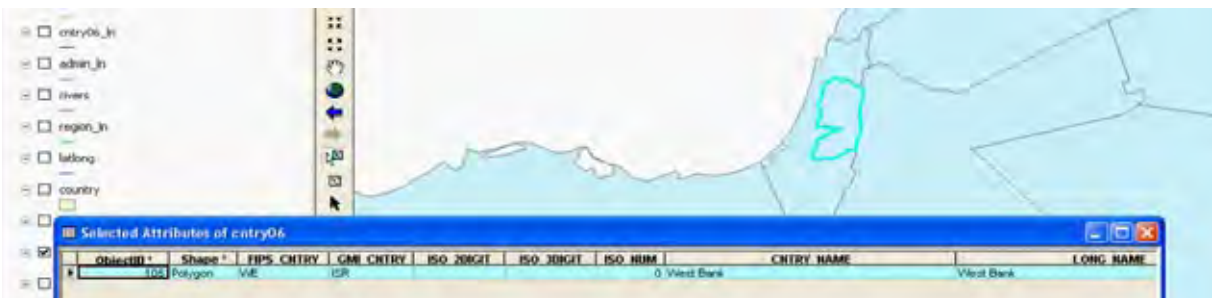
4. Zoom into the area we are at the moment.

5. Select with "identify" tool the different areas in Israel. Look to the attributes.

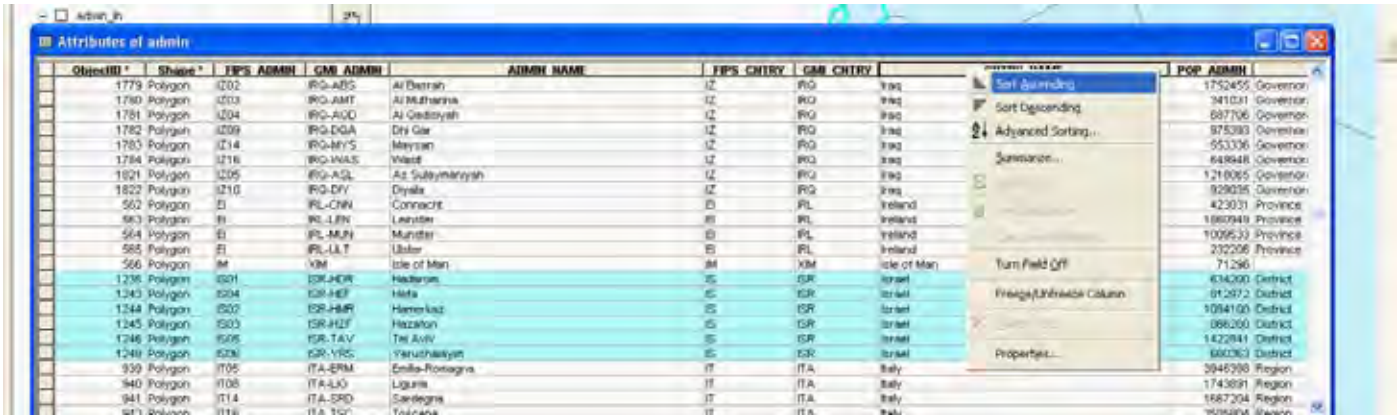



6. Open the attribute table of the theme.RCL on the theme name and choose "open attribute table"

7. Select with "select features" tool one of the areas and click in the attribute table on "show selected"



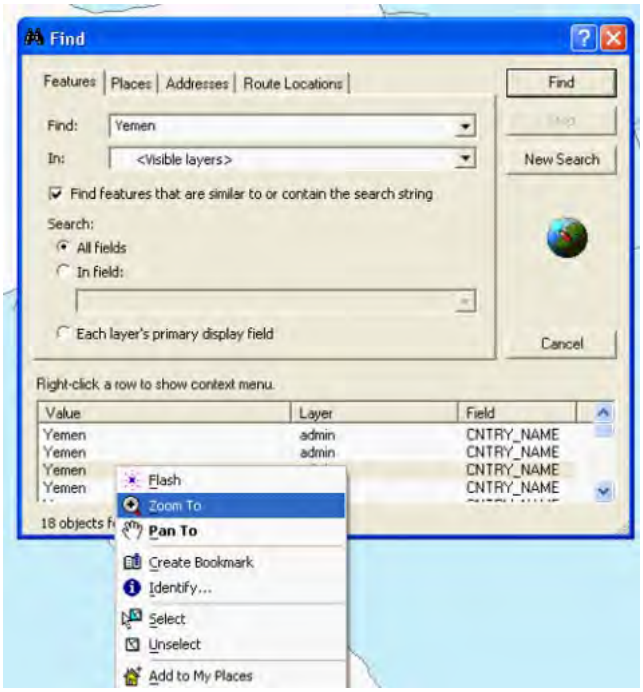
8. Check the box of the theme “admin” in the table of contents. Open the attribute table and go to the column “country name” RCL on the heading and choose “sort ascending” Scroll down to Israel. Select them all of them by pointing to the little grey field in the first column(field) and holding shift-button.




9. Look onto the map where the area is located.

Vector data can be easily selected and can contain attribute data. In a GIS there is an easy link between graphical presentation and attributes. You can easily answer the question: what is this object representing and where is the location of a certain object

10. To undo selections go to the main menu and choose selection/clear selected features




11. To find one object you can also use the binocular: on the tab page “features” Type “Yemen” and select *Find*.

12. Different items are found, DCL or RCL and let it flash.

***Assignment:***

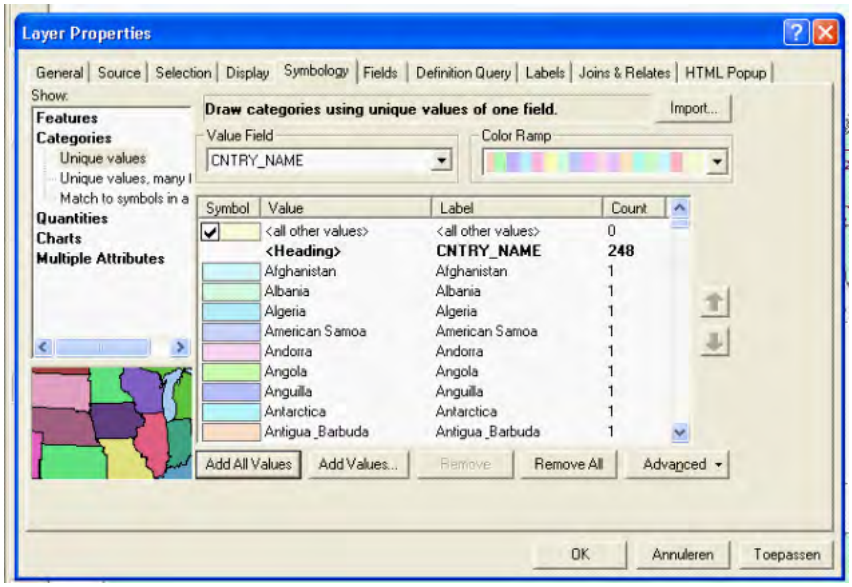
- Check the box of the theme “cntry06” and “rivers”, uncheck the theme “admin”
- Look for the country “Iraq” and try to identify the rivers in this country.

*Solution: Tigris and Euphrates*

## c. Manipulating the Visual Presentation

1. Uncheck all themes except “country 06”

2. DCL the theme “country06” choose the tab page symbology, choose for categories, than for unique values, than you select the value field “country name” and check “add all values”.




3. Check the theme “continents” and make a symbology for this theme so that every continent gets a different color.

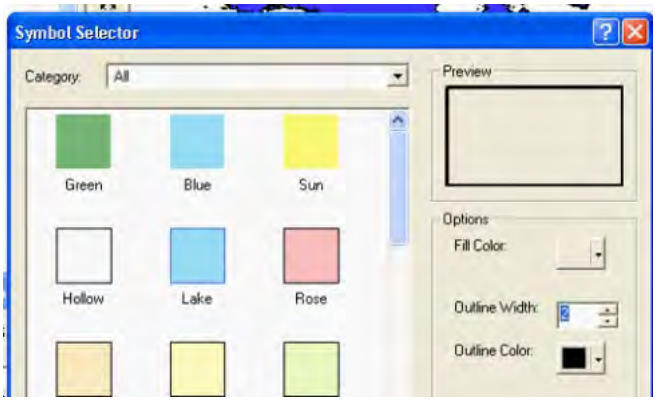
4. The continent theme covers the countrytheme. Now we want to see the countries upon the continents. We drag the theme “country06” in the table of contents upwards.

5. I want you to use another color pallet for the continents, some blue or brown colouring range.

6. Look in the symbology window to the box “color range” and choose one of the possible ranges.

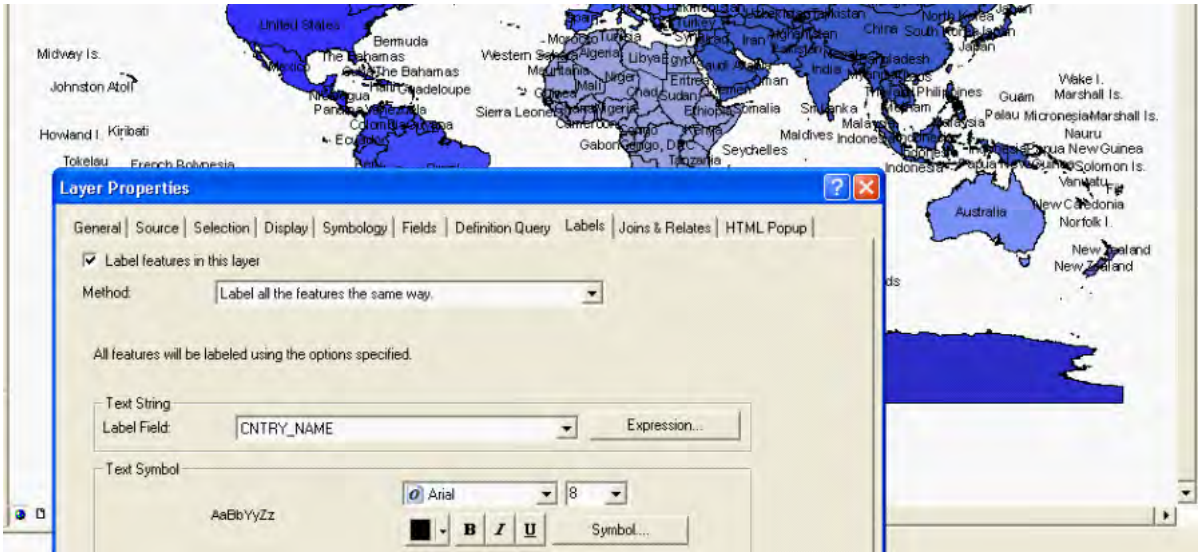
7. To see the countries and also the colors of the continents we must make the symbology of the countries transparent or hollow. Go to symbology, choose features and double click on the symbol, then choose “hollow”.

8. *I want to make the borderlines of the counties a little bit thicker.* Choose another value for "outline width"




9. *I want to label the countries:* RCL on the theme, choose properties and the tab page "labels"

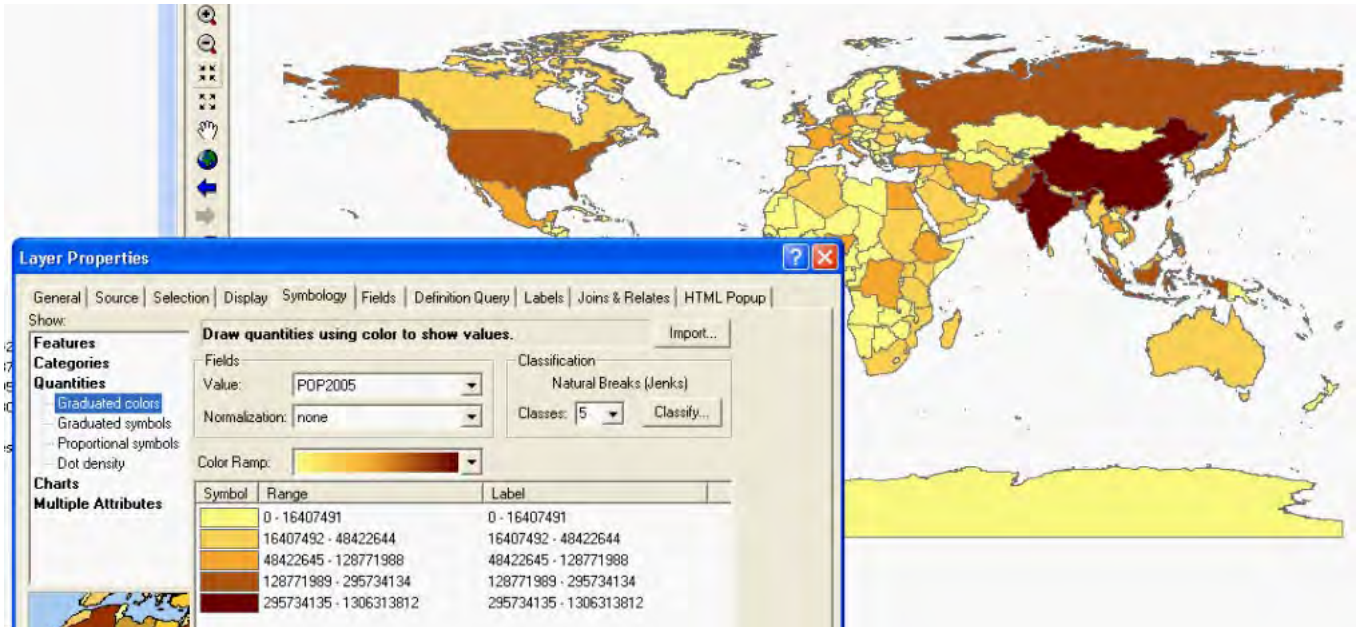
10. Check the box at the top of the tab page and choose the field that you want to use for labelling.




11. We can also use the attributes to colour the map gradually : f.e if you open the attribute table of country06 and you look to the different fields, you see the field pop2005.

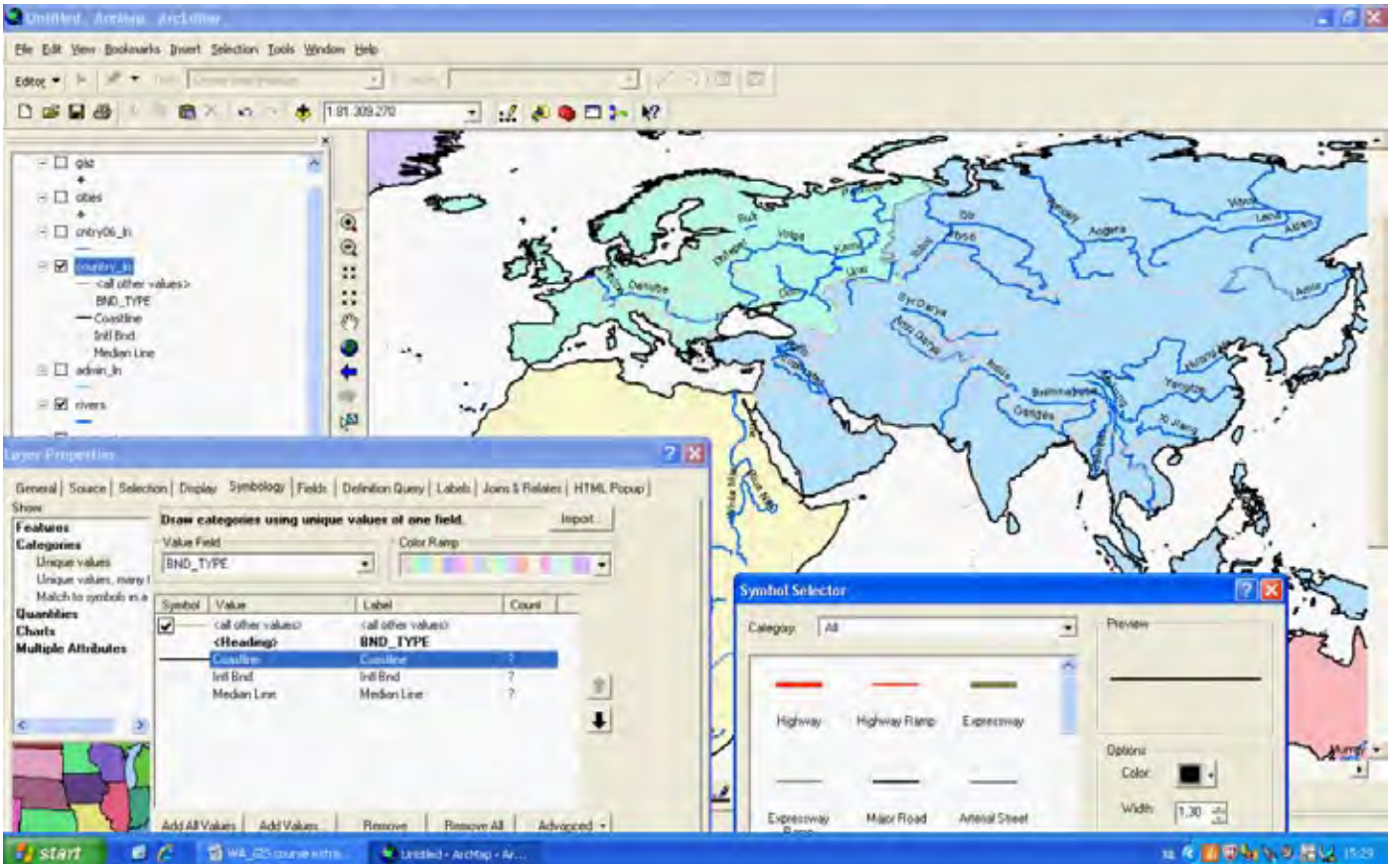
12. We can use the numbers that are in this field to colour the map gradually. Properties/ symbology, choose for quantities-graduated color.

13. You can see on one glance that the countries China and India have the biggest population.



### *Assignment:*

- Make a map of the world were the continents are labelled and have different colours.
- The rivers must be presented in thick blue lines and labelled.
- The theme "country lines" contains the borderlines of each country. Some of these lines are coastlines; try to present these coastlines in a thick black line.



# d. Selecting Objects

1. You can select single objects on the map or in the attribute table.

2. Now we will learn to select a range of objects using queries.

3. We want to select the rivers with a length of more than 5000 km.

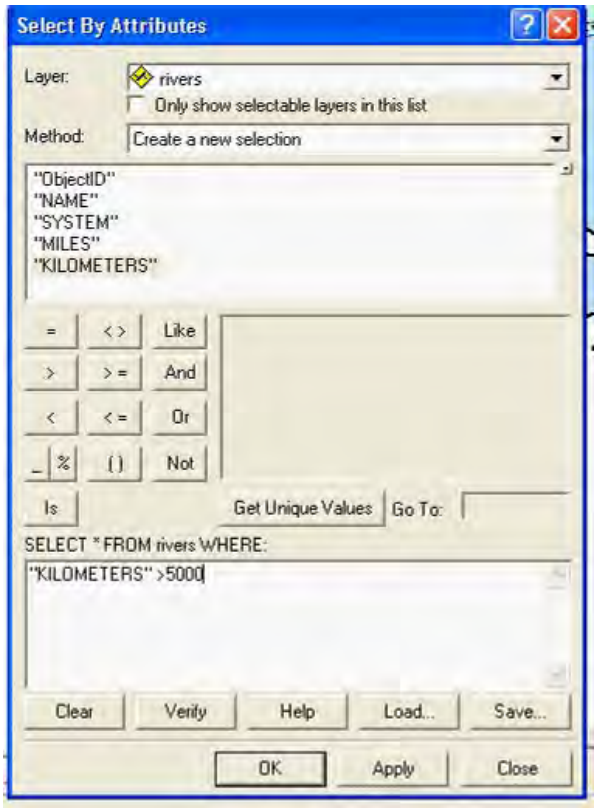
4. Go to the main menu and choose Selection/ select by attributes/

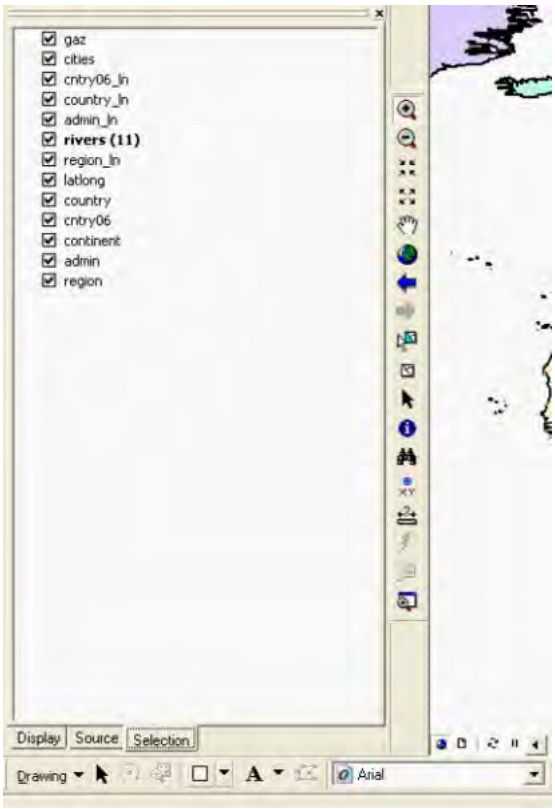
5. Type an SQL-expression in the empty box below.

6. The syntax of this expression must be completely correct, so the best way is to choose the separate elements of the query by double clicking. First select the correct layer

7. Than make sure the expression is as shown below.

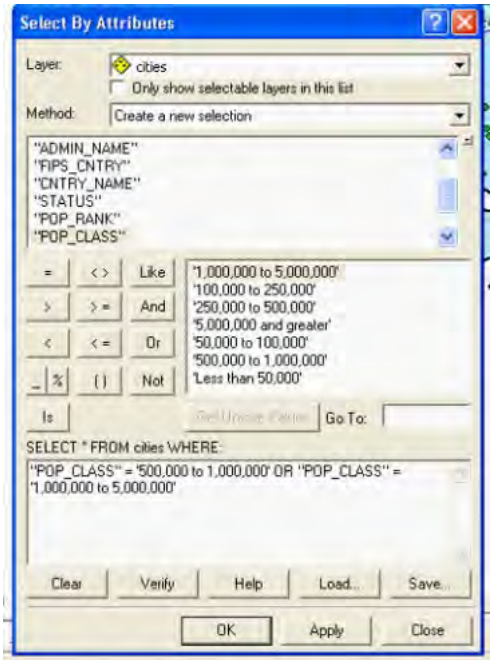
8. Look in the attribute table = 11 or look in TOC in the tab page selection.




9. Can you select the cities with more than 5 million of inhabitants?

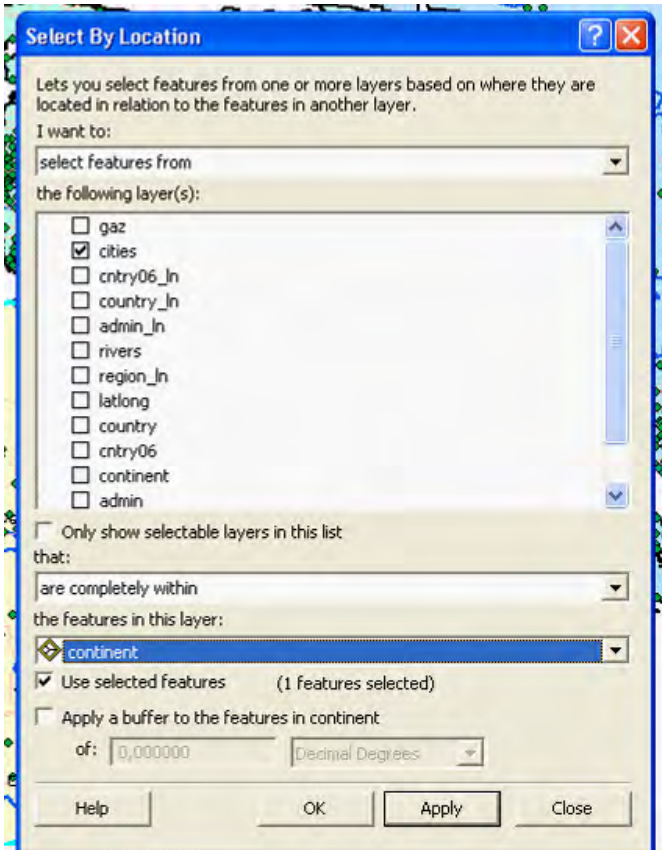
- No, the field "POP_class" is a string field and doesn't contain real numbers. If you want to know the number of cities with more than 500000 of inhabitants, what shall you do?
- The expression must be Pop_class = 500.000 to 1 million OR Pop_class = 1 miljon to 5 million : 370




***The former selections were based on the values of certain fields in the attribute table. This kind of selections are also possible in regular databases. The advantage of GIS is that we can also make selections, only based on common location.***

10. Let's make a selection by location: e.g. which cities are in Africa?

- First clear the selections that were made before.
- Main menu / selection/clear selected features
- Than go to the continent-theme and select the continent of Africa.
- Than select by location: "select features from cities that are completely within the features in the layer continent that are selected": result must be 637.



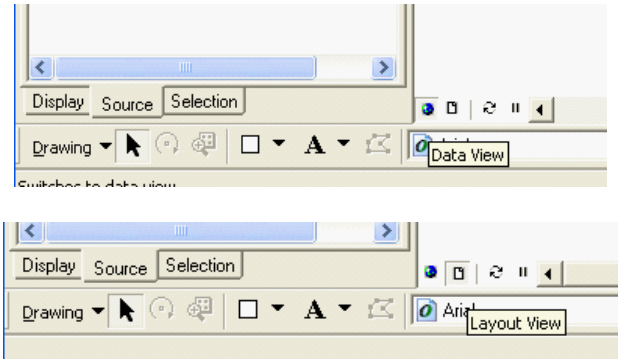

***This is one of the assets of a GIS: you can query data on the basis of location, there is no need of a field in the attribute table.***

### *Assignment*

- How many cities are lying in the united Arab emirates? *7*
- What is the country with the most inhabitants? *China*
- How many rivers are lying completely in this country? *1*
- How many rivers intersect with this country? *11*

### *Making a layout and exporting the layout to a jpg.*

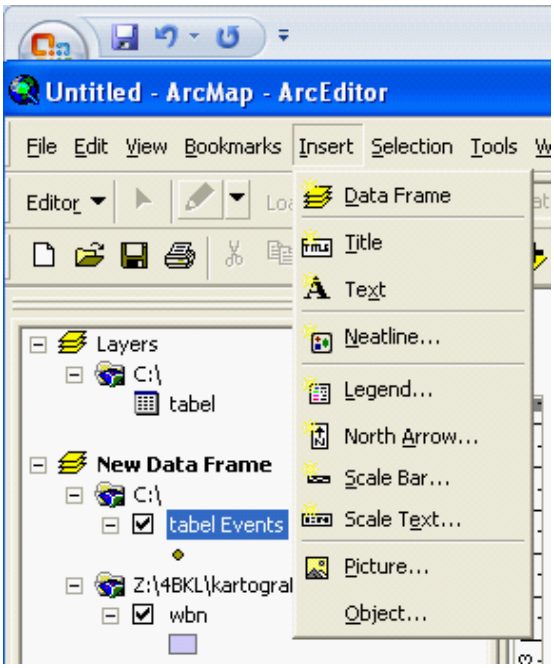
1. Choose the tab to go to the layout view.




2. You can explore now the possibilities to create a beautiful layout, using the command “insert”.

3. You can add a north arrow, a title, a scale bar, a legend and so on.

4. The zooming has to be done in the data-view, this was the normal view when we start up ArcMap.



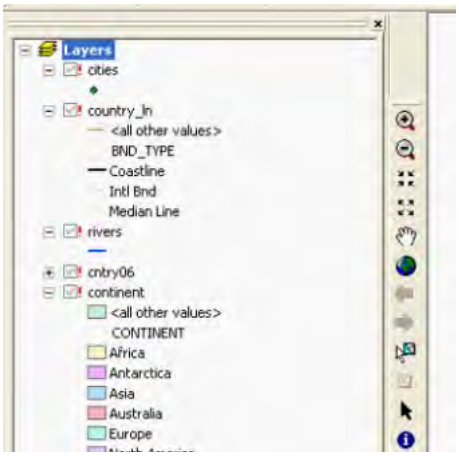

5. If your layout is satisfactory, you can make an image by clicking File/export Map and select the resolution and the format you want, and also the address

## e. Saving Projects

1. You can save a project as “name.mxd” The extension is *.mxd

2. This file contains no data, it just contains the names and locations of the themes that are used and the set up data such as used symbology, labelling, selections etc.

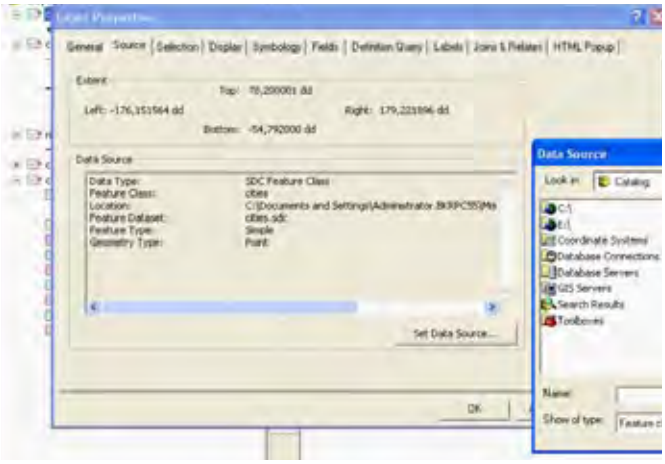
3. If you change the location of the data and try to open an existing project, the TOC appears correctly but there seem not to be any data visible.



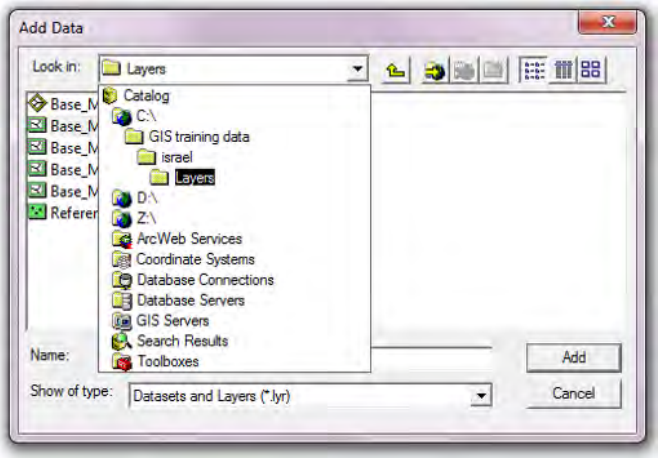

4. The check boxes in the TOC are grey and there is a red exclamation mark.

5. To make the data visible you need to change the description of the source.

6. RCL on the theme name, choose properties/ source and “set data source”. Than browse until you find the place where the data was placed.



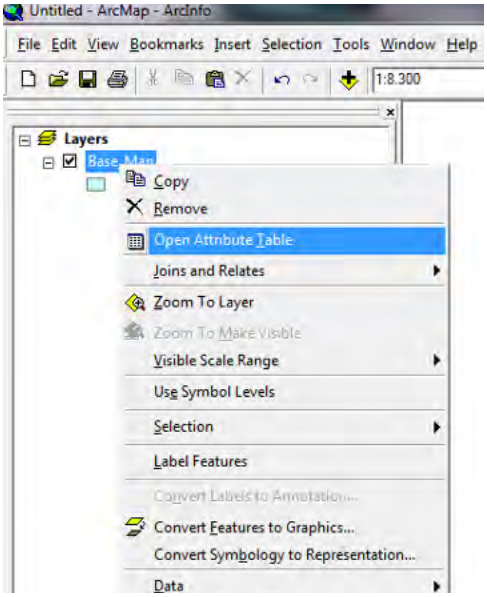
# f. Extra exercise with data of Jerusalem

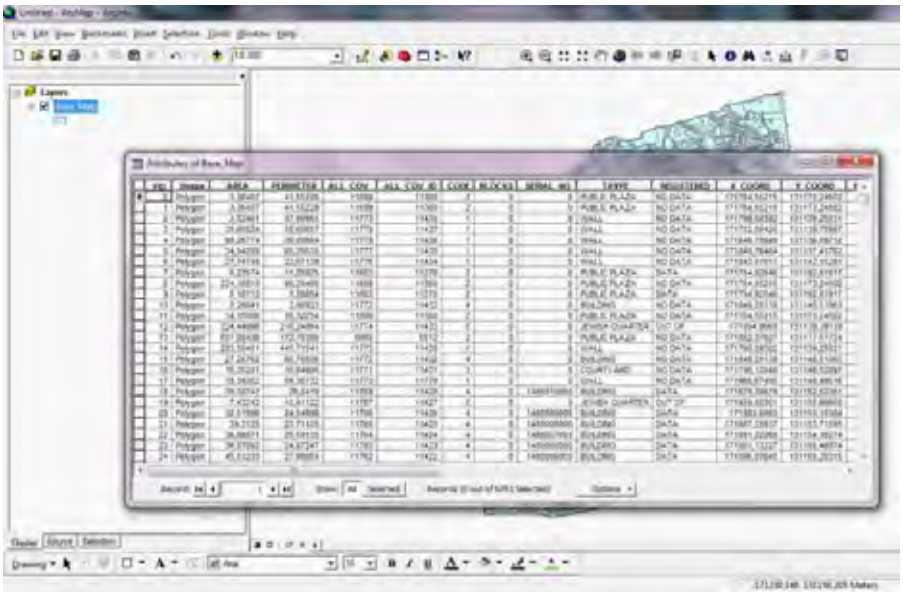



1. First thing to do when you get some data is look what attributes are with these data.

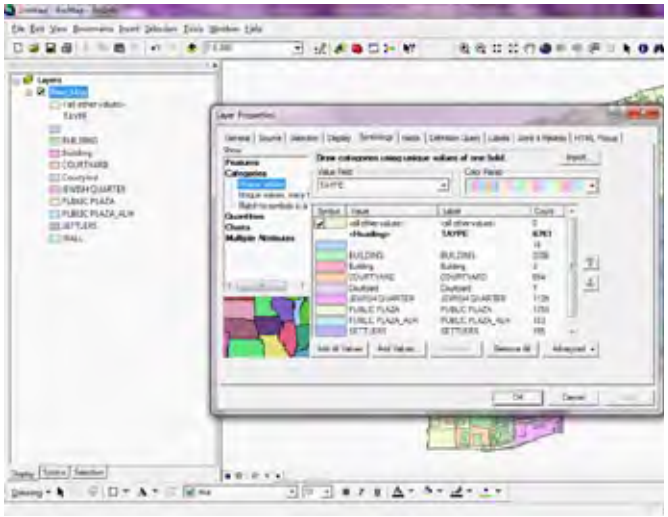
2. Add the data in the map Israel/layers/base map

3. Open the attribute table and look to the different fields and their values.



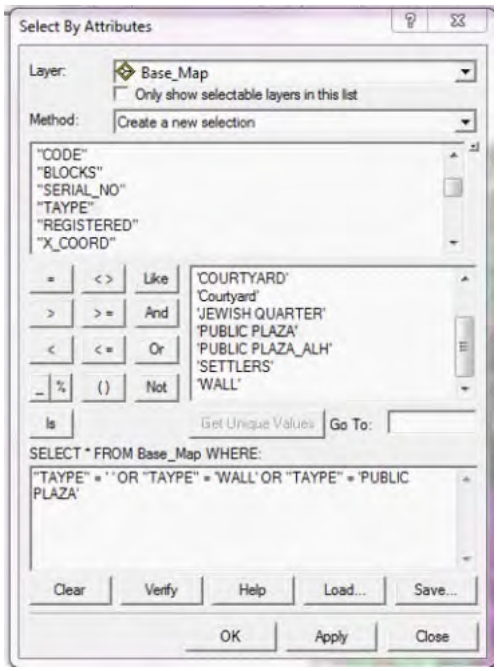
4. Choose another color to different values of the field type. One color is given to the records that has no value in the field type, so we suppose this value is unknown for these objects



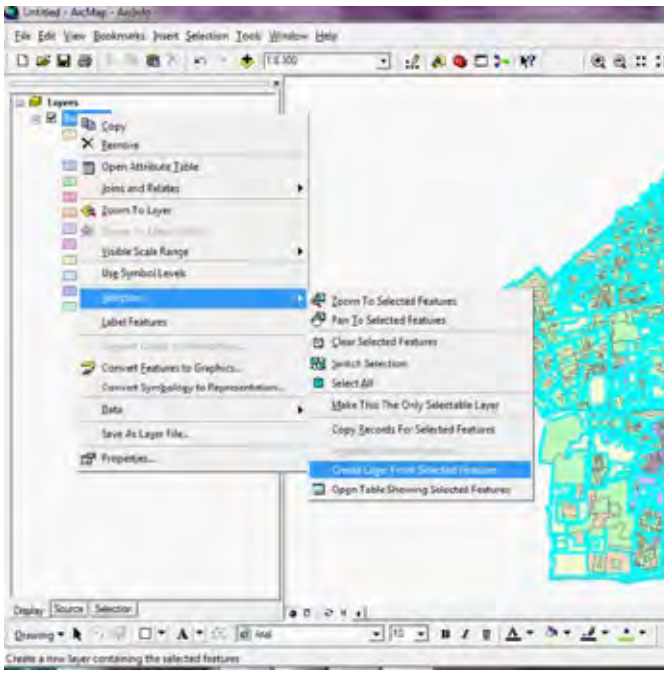
***We are going to make a layout to show the exact location of the buildings that have no value in this field, so someone can go and visit this buildings and lookup what value is needed to fill in.***

5. We will make a selection of objects wall, public plaza and unknown. Select -> select by attributes

6. “taype” = ‘ ‘ OR “taype”=’wall’OR “taype”=’public plaza’ -> Apply -> OK

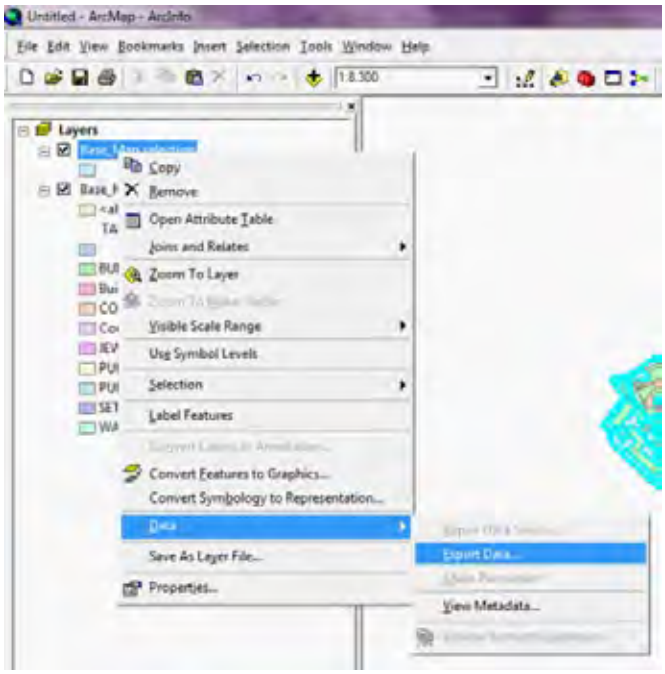


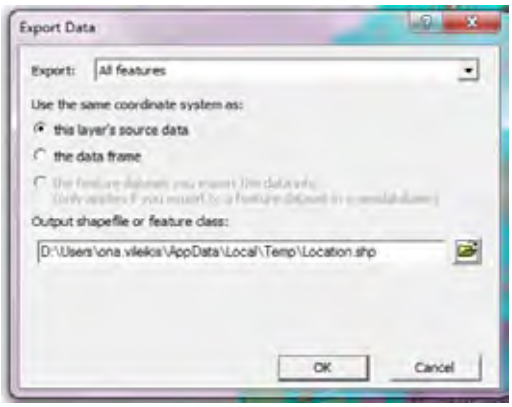

7. Right click on the name of the theme , choose selection and “create layer from selected features” A new theme was created.




***A new theme will appear. But the program has not asked for a place to save this new layer, so it doesn’t exist as a separate layer. If we want to make a new theme from this selected data, we have to export it as a new theme.***

8. Right Click on the selection layer -> Data -> export data -> give a name and a location. Export it as a layer.



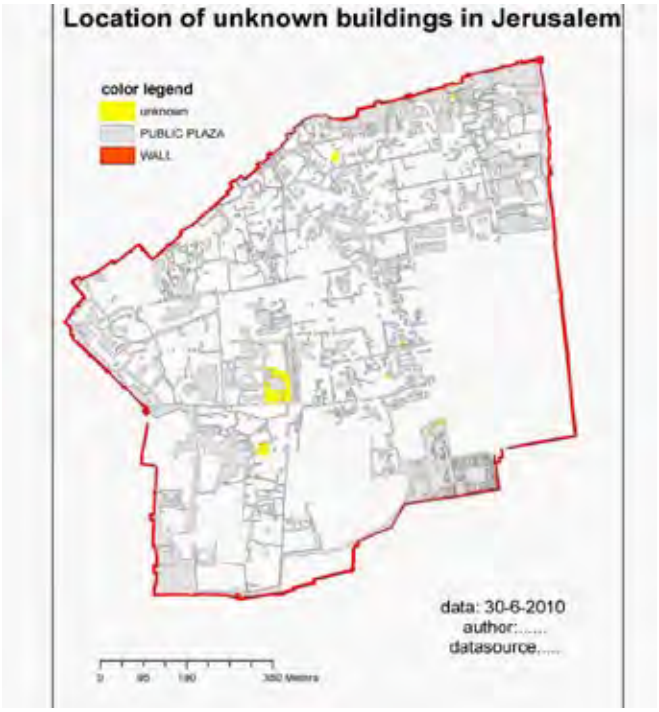

9. Turn-off the layers that you don’t need (Base Map).

10. Change symbols to make the map cleaner.

- Wall -> red and outline also red and 3 thick
- Public plaza -> grey
- ‘ ‘ -> yellow and outline also yellow and 3 thick
- Put in an alias for ‘ ‘: ‘unknown’

11. Go to the layout view and insert legend, title, scale bar and text (See next page).

***It is very important for any map that you give some metadata on the map: date, source of the data, author***




## *Changing coordinate systems*

***Data "Jerusalem"***

Note: Before this exercise you have to understand some principles of geodesy and map projections.

***See presentation: "Geodesy introduction"***

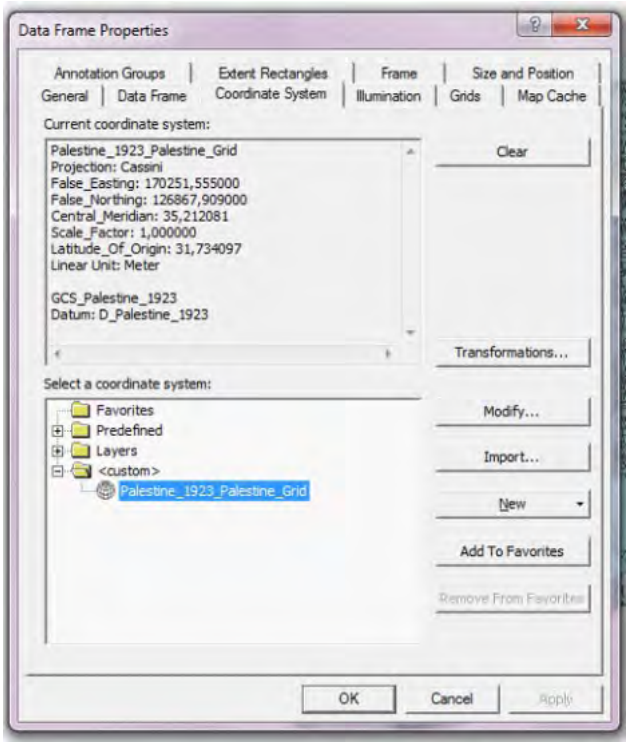
## *Exercise*

1. Open a new project.

2. Add the theme "base_map". Look to the coordinate system of the data frame (Layer Properties -> Source): it has a projected coordinate system Palestine grid. The dataframe takes always the coordinate system of the first theme you load in.

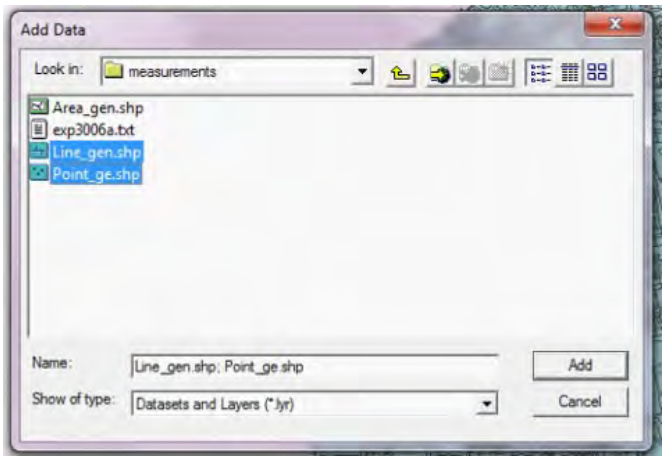
3. If you move the cursor and you look down right on your screen, you can see grid coordinates changing (meters).

4. For our own memory we will change the name of the dataframe to "Palestine grid".



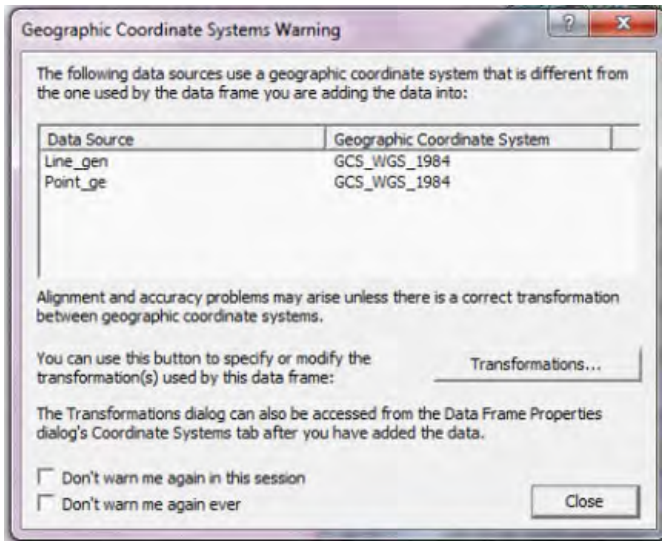
***We will now introduce the GPS- measurements we did in the fieldwork and walking on the Jerusalem wall.***

5. Add data: Israel/measurements/line and point themes.



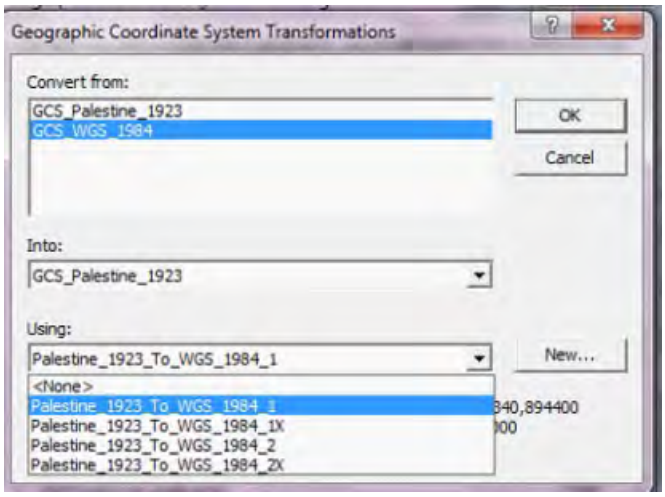

6. The window tells us that the coordinate system of this new data is not the same as the base map.

7. Indeed GPS Measurements always refer to the WGS Coordinate system. The geodetic datum that is used by WGS84 is another datum as the one that is used by the Palestinian grid. If we want the GPS Measurements correctly projected on to the Palestinian grid, we need to transform them from one datum to another.


Geographic Coordinate Systems Warning
The following data sources use a geographic coordinate system that is different from the one used by the data frame you are adding the data into:
Data Source
Geographic Coordinate System
Line_gen
GCS_WGS_1984
Point_ge
GCS_WGS_1984
Alignment and accuracy problems may arise unless there is a correct transformation between geographic coordinate systems.
You can use this button to specify or modify the transformation(s) used by this data frame:
Transformations...
The Transformations dialog can also be accessed from the Data Frame Properties dialog's Coordinate Systems tab after you have added the data.
Don't warn me again in this session
Don't warn me again ever
Close

***If you want a correct transformation:***

1. Click transformations… -> choose one.




2. We transform from WGS84 (the GPS-datum) to the datum that is the basis for the Palestine grid projection and we choose one of the transformation sets.

3. Normally the data is fitting reasonably good. If you zoom in at the wall, you see the GPS limited accuracy. The SBAS-system of EGNOS was working but not on every place, so mostly accuracy is better than 1m but sometimes there are bigger outliers.

***In the second part of the exercise we will start with the GPS Measurements and transform the Jerusalem-base map to the WGS Coordinate system.***

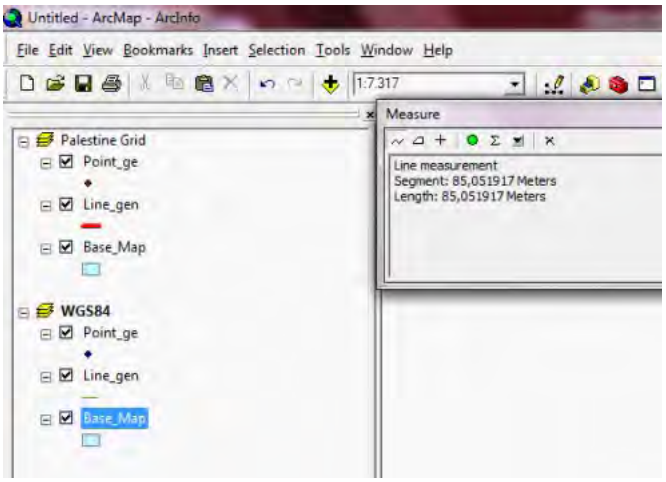
1. Create a new dataframe and put in the GPS-measurements as first (Point and Line).

2. Check the coordinate system of the data frame. It should be WGS84.

3. Change the name of the data frame to "WGS84"

4. Copy the base map from the first dataframe to the new one and look to the result.

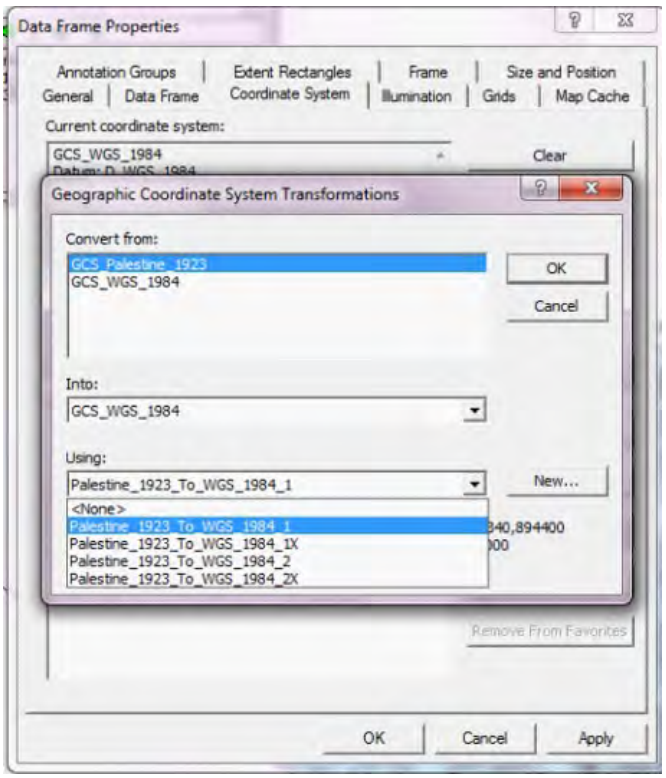
- There should be a shift. How many meters is this shift ?(85m in one direction)



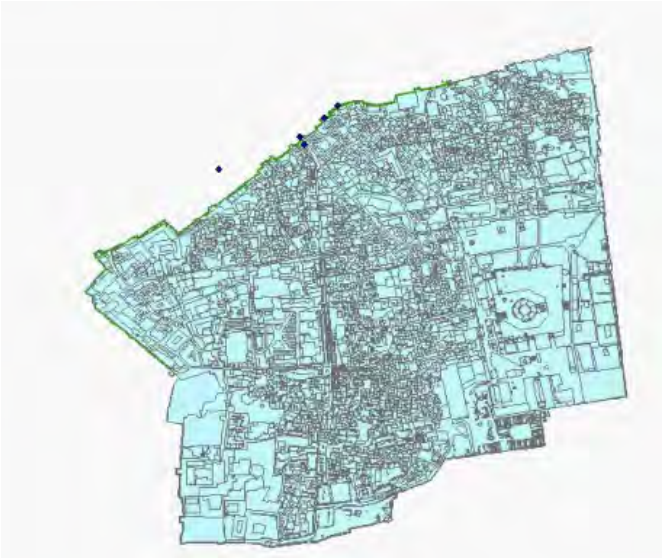

***How can we fix this shift. It has to do with the datum transformation. The program has calculated the geographic coordinates of every line and point of our base map, starting from the projected grid coordinates, but in the wrong datum. We need to tell that there has to be done some datum transformation, from Palestine datum to WGS-datum.***

5. Right click on the data frame "WGS84" choose for properties and the tab-page coordinate system.

6. Click on transformations and choose a transformation going from Palestine grid to WGS84, apply and you will see disappear the shift.




***This should be the final result***



# g. Convert to KML: Google Earth

1. Open Arc Toolbox

2. Choose conversion tools/To KML/layer to KML

3. Select the name of the layer you want to convert.

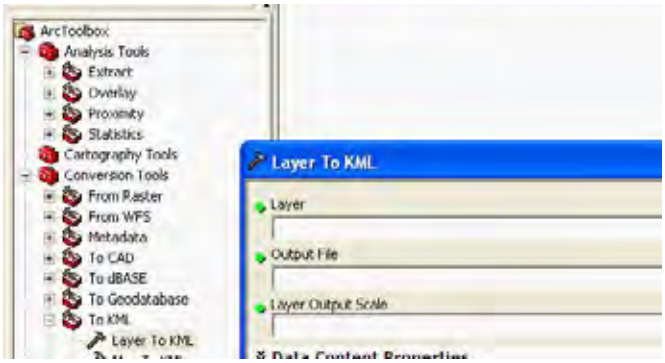
4. Give a name and address to the new file, it will have the extension *.kmz

5. Choose a scale for Google earth for zooming in when opening the file f.e. 1000.

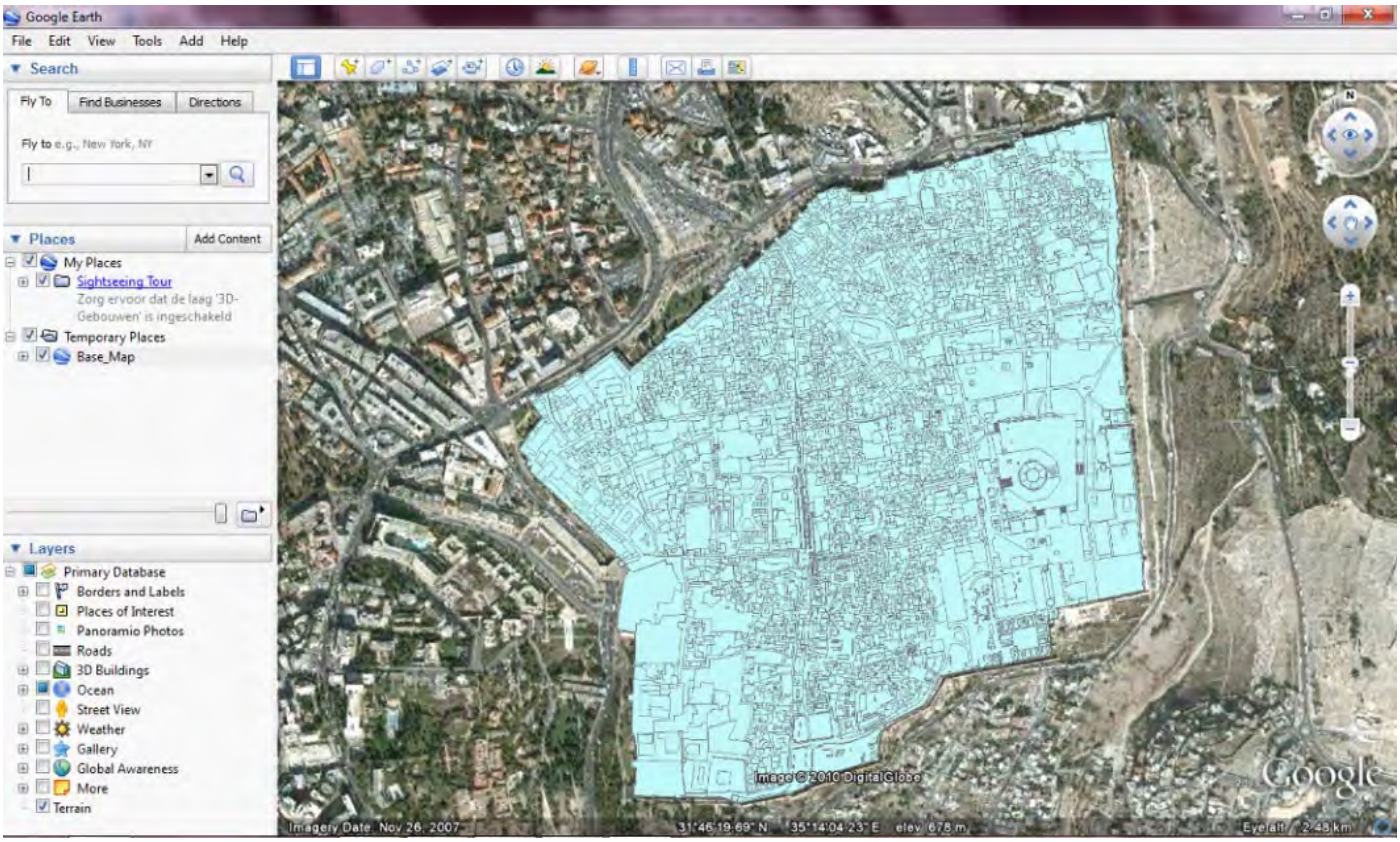
6. Click OK, the kmz-file is being created now.

7. Open windows explorer, look for the kmz-file you just made and click on it.

8. Google earth will open and zoom to this file automatically.



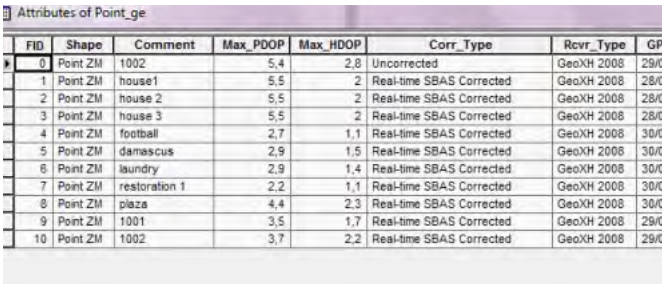

***Final result with Jerusalem example:***



# h. Make Hyperlinks to Photo's

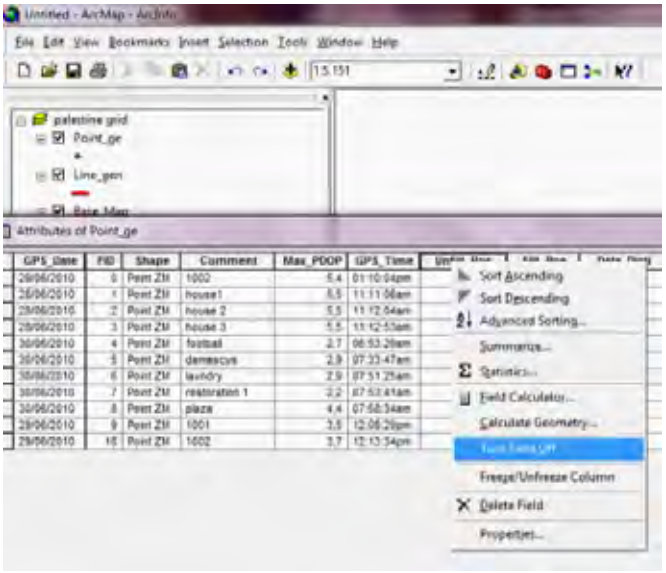
***As preparation make sure that a map "GIS photos" is under C:\GIS training data\israel***

1. Open the attribute table of the point-theme that was measured with GPS (WGS84).

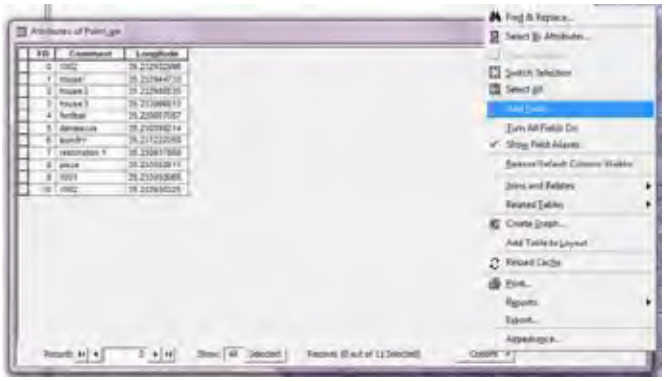

Attributes of Point_ge

| FID | Shape | Comment | Max_PDOP | Max_HDOP | Corr_Type | Rcvr_Type | GP |
|---|---|---|---|---|---|---|---|
| 0 | Point ZM | 1002 | 5,4 | 2,8 | Uncorrected | GeoXH 2008 | 29/0 |
| 1 | Point ZM | house1 | 5,5 | 2 | Real-time SBAS Corrected | GeoXH 2008 | 28/0 |
| 2 | Point ZM | house 2 | 5,5 | 2 | Real-time SBAS Corrected | GeoXH 2008 | 28/0 |
| 3 | Point ZM | house 3 | 5,5 | 2 | Real-time SBAS Corrected | GeoXH 2008 | 28/0 |
| 4 | Point ZM | football | 2,7 | 1,1 | Real-time SBAS Corrected | GeoXH 2008 | 30/0 |
| 5 | Point ZM | damascus | 2,9 | 1,5 | Real-time SBAS Corrected | GeoXH 2008 | 30/0 |
| 6 | Point ZM | laundry | 2,9 | 1,4 | Real-time SBAS Corrected | GeoXH 2008 | 30/0 |
| 7 | Point ZM | restoration 1 | 2,2 | 1,1 | Real-time SBAS Corrected | GeoXH 2008 | 30/0 |
| 8 | Point ZM | plaza | 4,4 | 2,3 | Real-time SBAS Corrected | GeoXH 2008 | 30/0 |
| 9 | Point ZM | 1001 | 3,5 | 1,7 | Real-time SBAS Corrected | GeoXH 2008 | 29/0 |
| 10 | Point ZM | 1002 | 3,7 | 2,2 | Real-time SBAS Corrected | GeoXH 2008 | 29/0 |

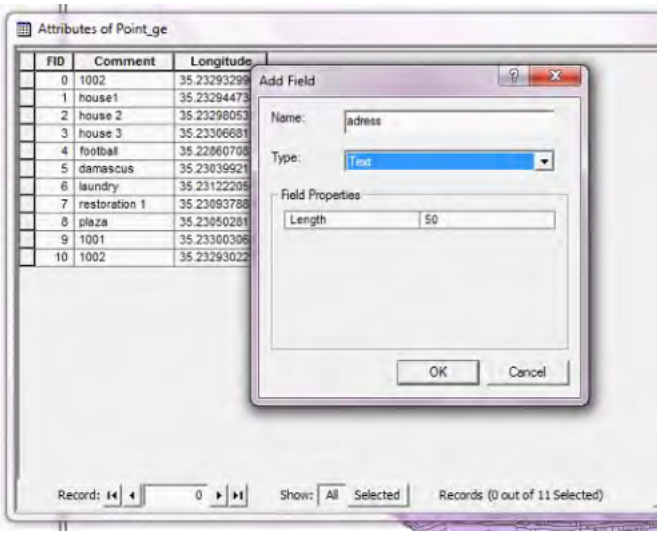
2. If you need more space you could turn-off fields by: Right click -> turn off field




3. Go to the bottom of the table and click options -> add field



4. Add a name (eg. Adress) -> select Text -> make sure that length is 100




***The new field has been inserted:***

Attributes of Point_ge

| FID | Comment | Longitude | adress |
|---|---|---|---|
| 0 | 1002 | 35.232932996 | |
| 1 | house1 | 35.232944738 | |
| 2 | house 2 | 35.232980535 | |
| 3 | house 3 | 35.233066813 | |
| 4 | football | 35.228607087 | |
| 5 | damascus | 35.230399214 | |
| 6 | laundry | 35.231222050 | |
| 7 | restoration 1 | 35.230937888 | |
| 8 | plaza | 35.230502811 | |
| 9 | 1001 | 35.233003068 | |
| 10 | 1002 | 35.232930225 | |

5. Right Click on the headings of a few fields so you can see the fields "comment" and "adress" at the same time

6. Start editor

7. Choose the source of data that contains the point-shapefile that you are going to edit.

8. Type in the field "address" from the record "football":C:\GIStrainingdata\israel\GIS photos\IMG_0998.JPG

Attributes of Point_ge

| FID | Comment | Latitude | Longitude | photo |
|---|---|---|---|---|
| 0 | 1002 | 31.786172237 | 35.232932996 | |
| 1 | house1 | 31.786254690 | 35.232944738 | |
| 2 | house 2 | 31.786249367 | 35.232980535 | |
| 3 | house 3 | 31.786328381 | 35.233066813 | C:\GIS training data\israel\GIS photos\IMG_1007.JPG |
| 4 | football | 31.781099917 | 35.228607087 | C:\GIS training data\israel\GIS photos\IMG_0998.JPG |
| 5 | damascus | 31.781799042 | 35.230399214 | C:\GIS training data\israel\GIS photos\IMG_0999.JPG |
| 6 | laundry | 31.782474036 | 35.231222050 | C:\GIS training data\israel\GIS photos\IMG_1001.JPG |
| 7 | restoration 1 | 31.782207906 | 35.230937888 | C:\GIS training data\israel\GIS photos\IMG_1002.JPG |
| 8 | plaza | 31.781639281 | 35.230502811 | C:\GIS training data\israel\GIS photos\IMG_1003.JPG |
| 9 | 1001 | 31.786248160 | 35.233003068 | |
| 10 | 1002 | 31.786197988 | 35.232930225 | |

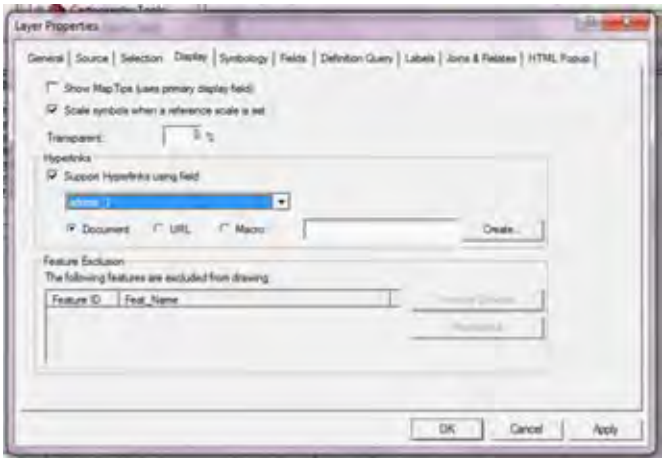
9. Make sure that the other records contain the right location.

10. Stop editing and save edits.

11. Go to the properties of the point-theme, choose the tab-page display

12. Check the box “support hyperlinks” and choose the field that contains the address of the photo’s.

13. Check “document”.

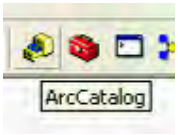


14. Go to the tab-page label and make sure that the points are labelled with the value of the field “comment”.

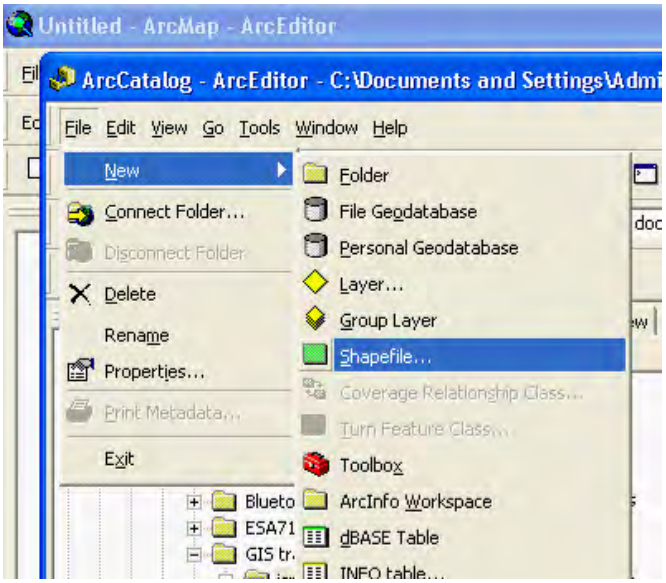
***Everything is ready now, you look on the toolbar for the lightening symbol, it must be yellow.***

15. Then you choose the identify tool, click on a point, scroll to the attribute “image” and click on the lightening symbol. Cross your fingers and the photo will appear!

## i. Making new points by digitizing on an existing background.

1. Open ArcCatalog 


2. Make a new shapefile- point

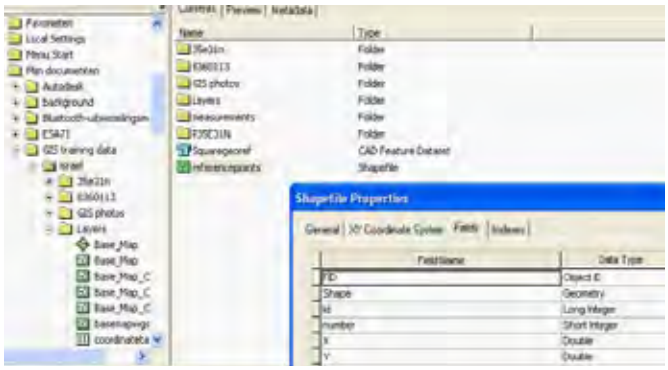



3. Give it a name e.g. reference points

4. Choose as coordinate system: projected coordinate systems/ national grid/Palestine grid

5. When the shapefile has been made, double click on it and define some extra fields.

Number – short integer
X – double
Y- double

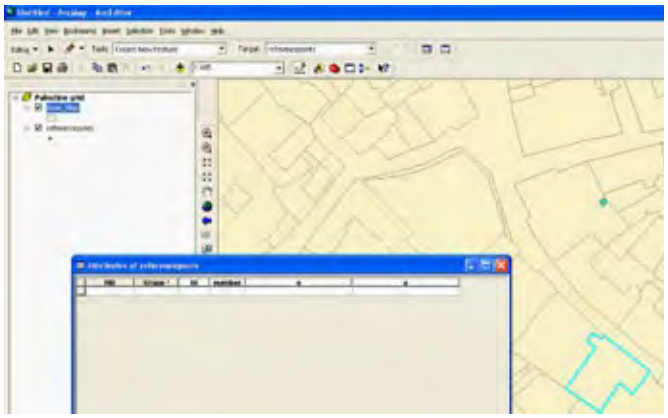


6. Drag the new shapefile into the dataframe of the Jerusalem data ( Palestine grid-projection)

- If you open the attribute table of the new point theme, you will recognize the fields you created but there is nothing in yet.

7. Zoom in on the street of the WA Office

8. Start editing- make sure that you choose the right source to edit the theme of the reference points (target).



9. Click on editor and choose snapping- set snappings of the layer" base_map"- vertex

10. Click on the pencil and snap to some well defined points in the streetcrossing.

11. Open the attribute table- give numbers to the points and save edits.

12. Label the points and choose a clear symbols- you should have next image.

13. Open the attribute table

14. Set cursor on the head of the field X – Right Click and choose calculate geometry

15. Make sure the right coordinate system is used. Do the same for the Y-coordinate.

- You have to use these coordinates to make a resection with your total station when you want to georeference the measurements of the total station in your national grid. **This is an alternative for georeferencing measurements with GPS**.
- Check whether there is a difference between the base-map and the existing situation on the field. Sometimes the elements are not exactly represented in the base map.
- It is important that you always **verify the situation on the field regarding to the map**. Some buildings could have changed after the making of the map, some details could have been forgotten. The map is probably made starting from aerial photographs and not everything is as clear visible from above.
- After checking the real situation the points were digitized again and the result was much better.

*Correct*

*Wrong*

# j. Making a point-shapefile starting from a table with coordinates

***In the old city we have the base map and we can choose recognizable points to make a resection with the total station.***

***The steps to follow are:***

1. Choose clearly recognizable points in the map; be sure the points you choose are reliable.

2. Get their coordinates (RCL on the field header and calculate geometry) .

3. Put up your total station in a local coordinate system.

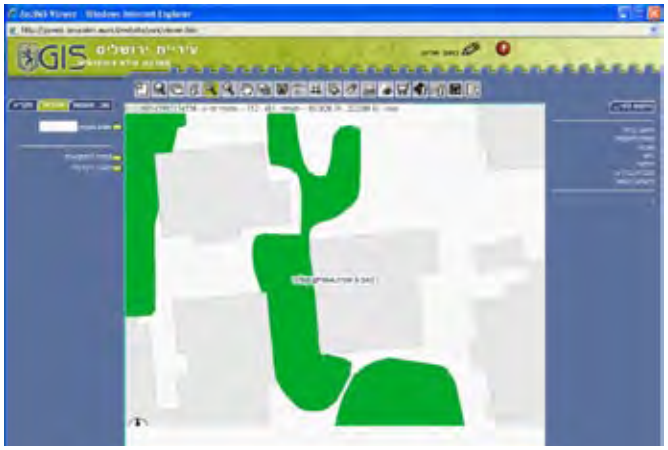
4. Measure the reference points.

5. Make an Autocad drawing.

6. Transform the Autocad drawing to the coordinate system of the reference points.

7. Add the Autocad-dwg to ArcMap.

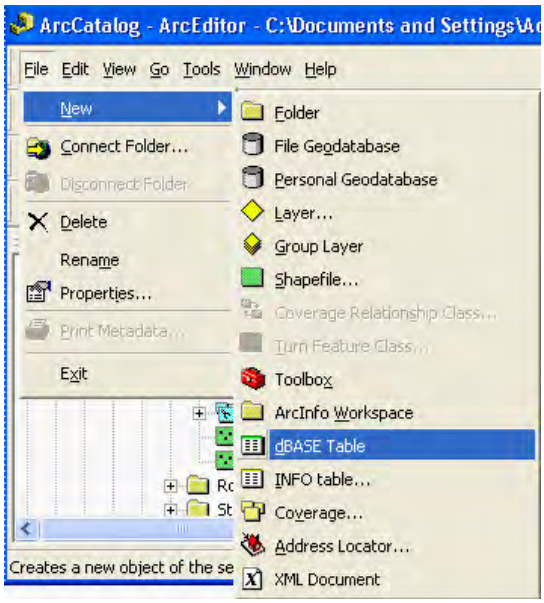
***Outside the old city we don't have a base map, but we can look for recognizable points in the Israelian GIS-webservice.***



8. Zoom in the part of the city you are interested in and move the cursor to some recognizable points. You see coordinates at the top of the screen.

9. Note all the coordinates you need.

10. Make a dBase-table in ArcCatalog with x and y fields, and also a field with point number.

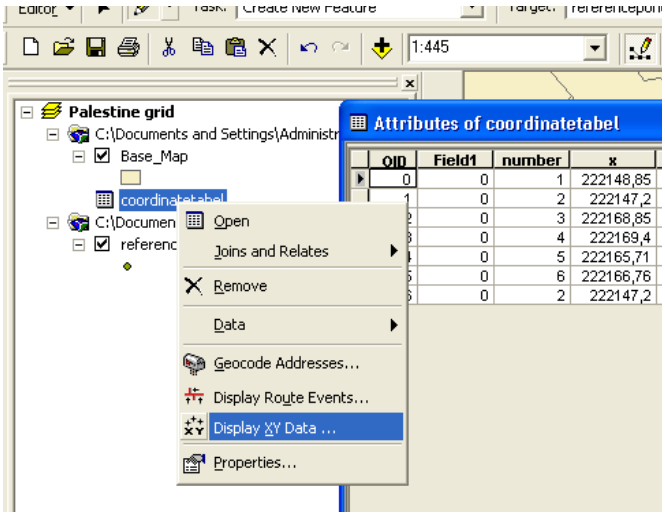



11. Insert the table in ArcMap and start editing mode.

12. Type the coordinates in the right fields (use comma)

13. Stop editing and save edits.

14. RCL on the name of the table in the TOC and choose for "display XY-data"



15. Choose the right coordinate system : it is the Israel TM grid

16. Look if the points are at the right place, a possible mistake is the changing of the order of x and y.

17. The file you just made is not yet a shape file. You have to export by RCL on the name of the point-theme that has been created. Choose for Data and then Export Data. Choose a place in your folder to put the new shapefile and press OK. You just made a point-shapefile. *Congratulations*!

# k. Extra exercise

### *Data : "Roma"*

You got some data from Italy and from Rome in particular. Add the following themes: edifices/churches/romaponte/trasteverestreets/italiaroads/romabuildings/santacecilia/flood…

### *We begin with a few assignments:*

- Churches: graduated color by number of visitors
- Label the theme romabuidings. Find the building of ICCROM
- Present the streets with a thick blue line.
- In the theme edifices you can see a condition in the TOC. Look if this information is included in the attribute table? How many buildings have some surface damage: code 2 – number = 9
- Look to the floodzones: give them a graduated color so that the lowest part has the most dark colour.
- Add the aerial photograph "RomeAreal2.tif" and look to the lowest part of the floodzone.
- How many churches are in the floodzone: try to select this church by making a select by location.

### *Rasterdata*

You zoom into the aerial photograph, until you see separate pixels. You click with the identify tool on a pixel, you get information about the red green blue value of the pixel. There is no information about what the pixel is representing. We call it a raster image.

- If you look in the TOC, there is no attribute table linked to the photograph.

### *Georeferencing*

- The aerial photograph fits with the other objects, it is georeferenced.
- Add mercanti.dwg/zoom to full extent/uncheck all boxes of the dwg-file
- You see Italy as a small unit.What has happened? The map of Italy and Rome is represented in WGS. If you move the cursor you see WGS-coordinates: geographical coordinates, latitude and longitude.
- The dwg is a CAD design . The coordinates of every point are numbers that signify centimeters or even millimeters. If I don't tell the GIS in which coordinate system this cad-file is built up, the GIS makes WGS coordinates from this numbers.Which has no meaning at all.
- The cadfile is not good georeferenced.

### *Hyperlinks*

- Go to the properties of "edifices" theme, look in the attribute table: you can find the field with a path description. It is also possible to make a field with a URL (internet

address).

- Go to the properties, tab page display, select the field where the hyperlink will look for his path.
- If you check the box, you see the thunderbolt is activated.
- Look for the building with the name “santasecilia” and aim with your thunderbolt on it.

### *Introducing data from GPS*

- Check the box of the riverwalk. You see points from separate GPS-measurements. If we look in the attribute table you can see some additional data such as GDOP, number of satellites etc.
- The points have coordinates in the WGS-system and this is also the coordinate system from the themes. it is possible to get an idea of accuracy by measuring distance when the points seem to deviate from a straight line : a few meters.

# 4. Global Positioning System (GPS) and Global Positioning Navigation Systems (GPNS)

*Check presentation: Introduction to GPS -GNSS*

### *What is Global Positioning System (GPS)?*

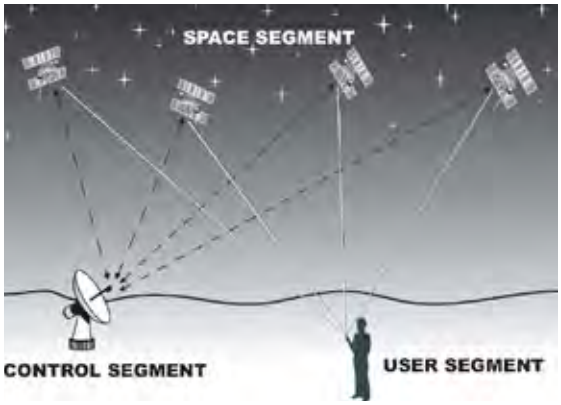
- The GNSS is often referred as GPS. However, the GPS is just one GNSS system developed by the US Department of Defence.
- The GPS receiver determines location on earth, receiving radiosignals from satellites.
- Not influenced by the weather, day or night.
- Well influenced by obstacles.
- Different systems and different accuracies.

### *GPS Nominal Constellation*

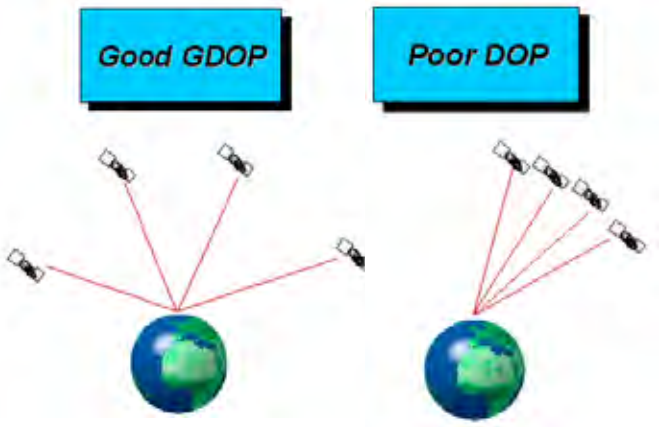
- The system is conformed of 24 satellites in 6 orbital places;
- 4 Satellites in each plane;
- 2,200km altitude and;
- 55 degree inclination.
- It works by measuring the distance between the GPS satellites and the user receiver.
- On every place on earth on every moment there are at least 4 satellites visible .

### *GNSS : Global Navigation Satellite Systems*

- GPS(31sat): USA
- Glonass(13sat): Sovjet Unie
- Beidou-1(4sat): China ->Compass (35sat)
- Galileo(30sat) : planned in Europe
- IRNSS: Indian Regional Navigational Satellite System (planned before 2012)
- QZSS:Quasi Zenith Satellite System –Japan (3sat)




### *GDOP : geometric dilution of precision*
### *The signal has to go through the ionosphere giving big errors. Therefore:*




- Signals are not powerful, so there must be direct contact or open sky ( no trees or narrow streets)
- Position is calculated referring to the position of satellites, this happens in a worldwide reference system: World Geodetic System (WGS)
- Signals pass through ionosphere and are subject to an unknown delay so position accuracy is varying from a few meters till 10 'ths of meters

### *Choosing the GPS Technique and/or device*

- Are there corrections available?
- Depends on your device ,where you are and if you want to pay for it.
- Do you need real time or is postprocessing possible?
- Is quality control on the field necessary or can you go back in case of failure?
- What is the required accuracy?
- WGS Coordinates are never more accurate than some meters
- Centimetres, decimetres do only make sense in a projected coordinate system

### *First category: Navigation devices*

- **Handheld navigation devices**
  1 standalone receiver
  Code-measurements
  Accuracy: meters (2-10°
  Application in car navigation, trekking

### *Second category : Mapping devices*

- **DGPS** uses corrections and improves accuracy -> submeter
- **Navigation** device integrated with GIS or mapping software
- **GIS software** is able to manipulate maps and linked databases

### *Third category : Surveying devices*

- **Phase measurements** in combination with code measurements ->centimetre accuracy
- Always two devices needed : **reference and rover**
  – Reference can transfer data by GSM or mobile internet ->real time GPS or RTK
  – Reference data can be combined with rover data in postprocessing ->static GPS measurements

# Architectural Heritage Recording Manuals:

a methodology for digital recording of buildings and monuments in Jerusalem

Mario Santana Quintero, Ona Vileikis & Guido Kips

The manuals aim at providing an approach for the effective use of recording, interpretation, and information management systems in the conservation of built heritage. It has been prepared for the **Welfare Association**.

Cultural heritage is a unique and irreplaceable source of information. The process of acquiring heritage information serves for the identification of heritage places with significance at the local, national and/or international community.

Good decisions in heritage conservation are based on timely, relevant and accurate information about the conditions, materials and evolution of heritage buildings and landscapes. Therefore, documenting, recording and analysis of heritage places is an essential part of their conservation and management.

The rapid rise in new digital technologies has revolutionized the practice of recording heritage places. Digital tools and media offer a myriad of new opportunities for collecting, analyzing and disseminating information about heritage sites. With these new opportunities, there are also conflicts, and an intense effort to build digital media into the education of conservation professionals. Issues regarding the proper, innovative and research-focused uses of digital media in heritage conservation are an urgent topic in the global heritage conservation field, and the University College St. Lieven and the Raymond Lemaire International centre for Conservation at the University of Leuven have played a leading role in this area of cross-disciplinary research and practice. This training course offer a unique opportunity for professionals of heritage institutions in the Welfare Association to learn new approaches, best practices, and research results in the area of heritage information.

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